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by Lt.-Col. L. URWICK, O.B.E., M.C., M.I.P.E.

FABRICATION AS APPLIED TO LIGHT AND MEDIUM SIZED COMPONENTS
by R. M. WATTS.

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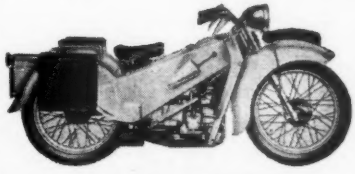

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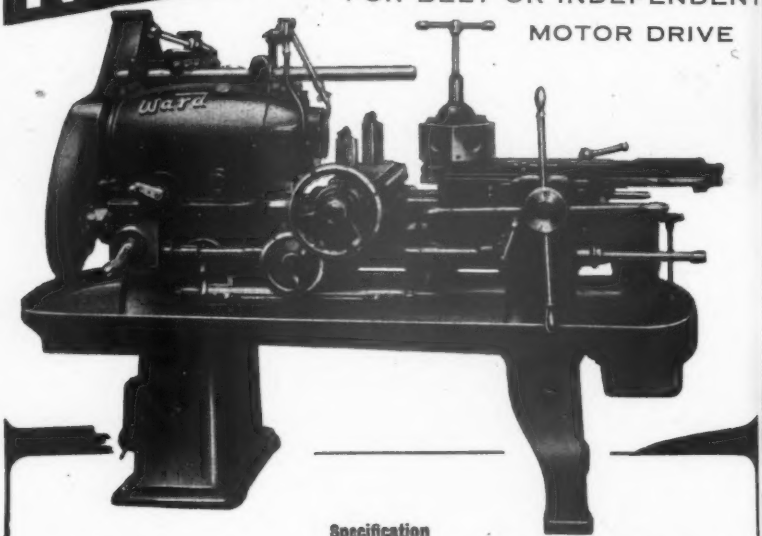

Specification

Height of centres	6½ in.
Dia. of hole through spindle	1⅝ in.
Dia. that automatic chuck will take up to	1½ in.
No. of spindle speeds forward and reverse	6
Range of spindle speeds	42 to 1650 r.p.m.
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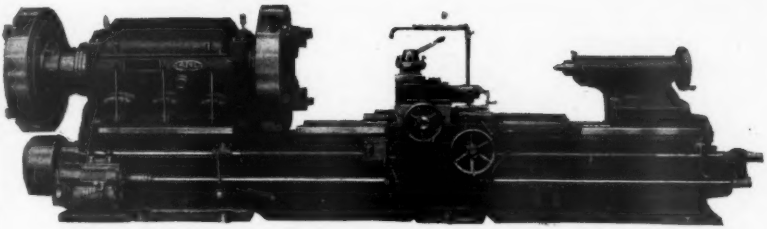

Our illustration shows the Lang 36-inch swing Oil Country Lathe which has a 12¼" dia. hole through the spindle. This machine is one of a series of four sizes ranging from 24-inch to 40-inch swing. All have ground gears and are fitted with special tapering attachment.

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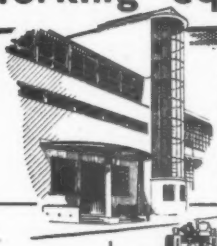

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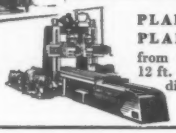

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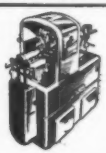

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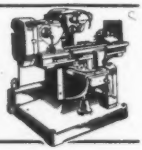

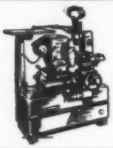

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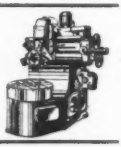

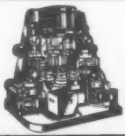

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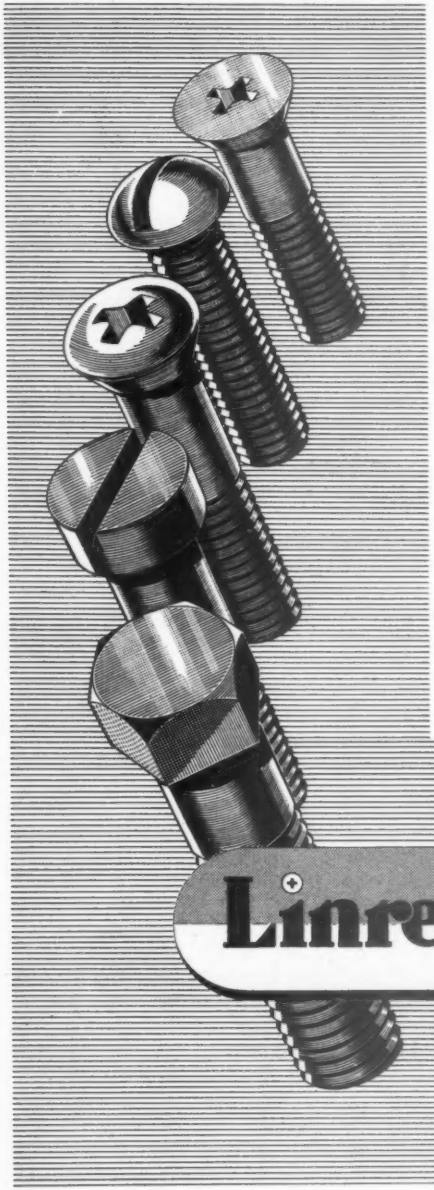

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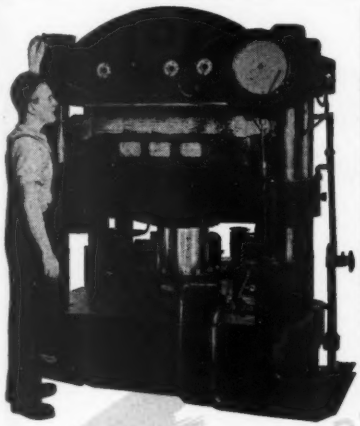

★ *A cold press of 200 tons capacity fitted with a 12" diameter ram—this unit is shown in action as an ejecting press stripping railway brake blocks from the hot dies after vulcanising.*

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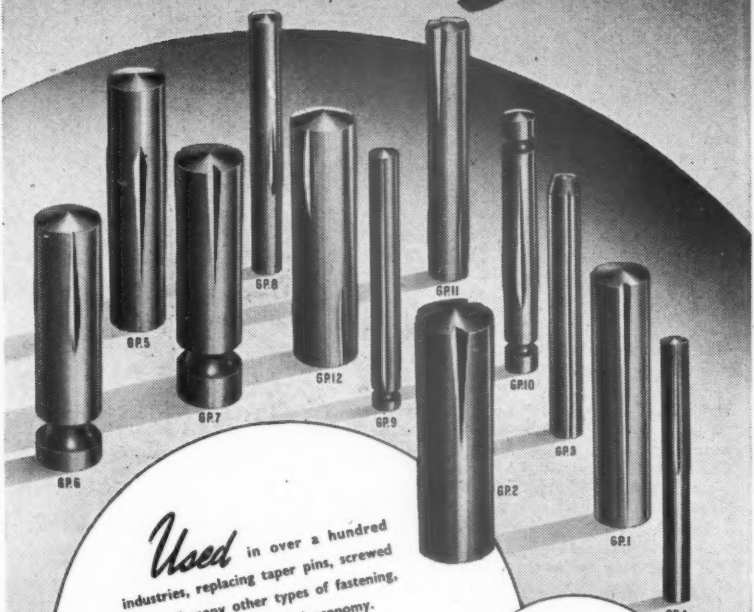

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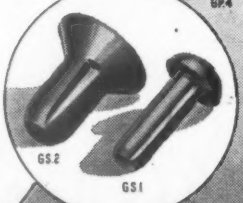

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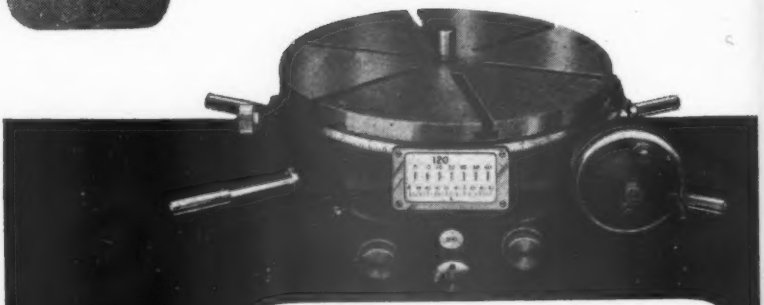

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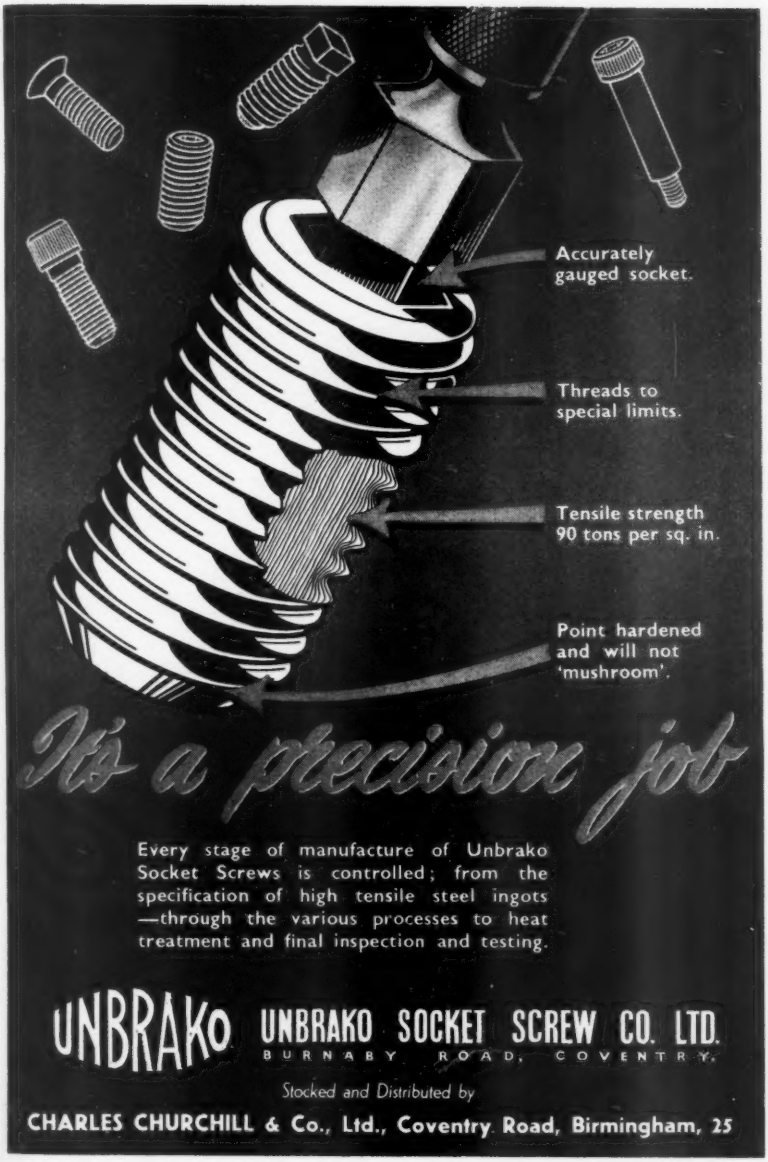
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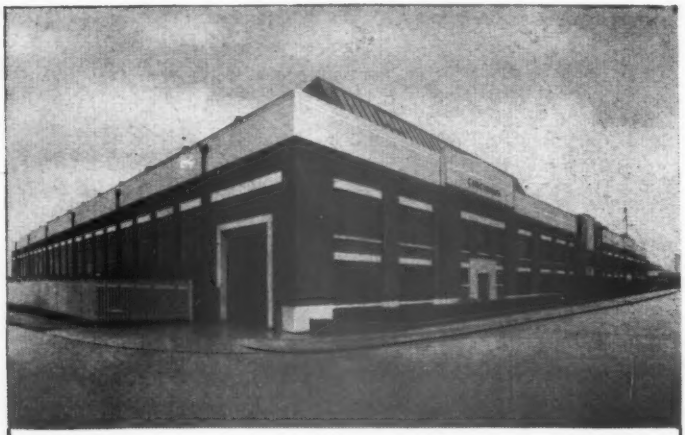

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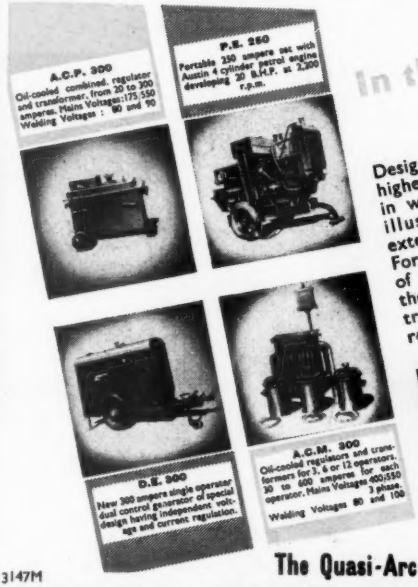
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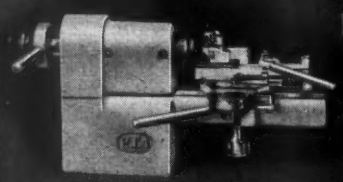

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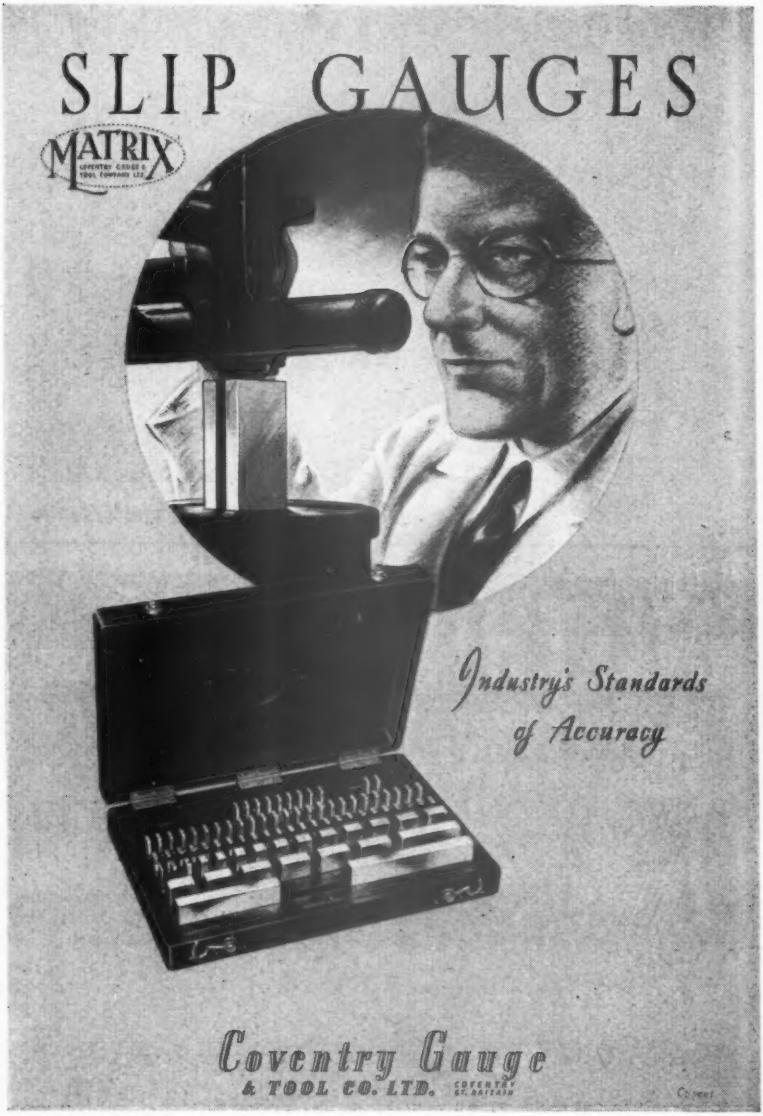
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F. Bloor, R. M. Buckle, B. H. Dyson, L. R. Evans, R. C. Fenton, W. V. Hodgson, E. J. H. Jones, M.B.E., R. Kirchner, Prof. T. U. Matthew, H. J. Swift, O.B.E., M. H. Taylor, S. Wright

Australian Sub-Council

President E. C. PARKINSON
Chairman E. L. OLFEN

Vice-Chairman
E. B. Richardson

Elected Members

H. le Cheminant
J. Finlay
S. D. McPhee
J. M. Steer
W. G. Davis
F. Glover
C. Pullen
J. E. Strick

South African Sub-Council

President A. B. ANDERSON
Vice-President A. C. WOTHERSPOON

Past Presidents

L. H. L. Badham J. Henry
D. Lion-Cachet

Elected Members

R. H. Arbuckle
P. F. Evans-Watt
W. Gillespie
D. A. Petrie
W. Caldwell
E. G. Fox
G. Godfrey
J. Renwick
H. H. Waters

Director and General Secretary of the Institution
Major C. B. Thorne, M.C.

Education Officer : T. B. Worth

Section Honorary Secretaries

Birmingham	A. J. Mansell, 204, Alcester Road South, Birmingham, 14.
Calcutta	J. Warren-Boulton, Machine Tools (India) Ltd., Stephen House, Dalhousie Square, Calcutta.
Cornwall	F. W. Spencer, "Pembroke," Phillack, Hayle, Cornwall.
Coventry	A. Hill, 382, Ansty Road, Coventry.
Derby Sub-Section	A. Short, 9, Laburnum Grove, Kingsway, Derby.
Dundee	A. H. Webster, 8, Kinnordy Terrace, Craigiebank, Dundee, Angus.
Eastern Counties	L. A. Childs, Crane Ltd., Nacton Road, Ipswich.
Edinburgh	P. H. Lee, 39, Corstorphine Bank Drive, Edinburgh, 12.
Glasgow	W. P. Kirkwood, "Morar," Sandfield Avenue, Milngavie, Dumbartonshire.
Halifax	Miss N. E. Bottom (acting), Hopkinsons, Ltd., Huddersfield.
Leicester and District	C. F. Gazard, 27, Stretton Road, Leicester.
Lincoln Sub-Section	E. E. Ingleton, "Glenroy," Lincoln Road, North Hykeham, Lincoln.
Liverpool	O. Blenkinsop, 119, North Barcombe Road, Childwall, Liverpool, 16.
London	H. W. Townsend, Philips Electrical Ltd,, New Road, Mitcham Junction, Surrey.
Luton and Bedford	R. M. Buckle, 238, Cutenhoe Road, Luton, Beds.
Manchester	H. E. Wheeler, 4, Marlfield Road, Grappenhall, Warrington, Lancs.
Melbourne (Victoria, Australia)	C. Pullen, 13, Immarna Road, Camberwell, E.6.
North Eastern	H. B. Topham, C. A. Parsons & Co., Ltd., Heaton Works, Newcastle, 6.
Northern Ireland	W. G. Wyman, "Linden Lea," Cultra, Co. Down.
Nottingham	C. N. T. Manfull, Chellaston House, Thurgarton Street, Nottingham.
Preston	F. M. Kemp, Clayton, Goodfellow & Co., Ltd., Atlas Iron Works, Blackburn, Lancs.
Sheffield	E. Levesley, 259, School Road, Sheffield, 10.
Shrewsbury Sub-Section	R. O. L. Cadman, 5, Perseverance Terrace, East Road, Ketley Bank, Oakengates, Salop.
South Africa	The Secretaries, Institution of Production Engineers, Barclays Bank Buildings, Corner Commissioner and Harrison Streets, Johannesburg.
Southern	S. Coates, 51, Westbury Road, Regent's Park, Shirley, Southampton.
South Wales and Monmouthshire	S. T. O. Davies, 4, St. Cadoc Road, Heath, Cardiff.
Sydney (New South Wales)	J. M. Steer, 260/262, Kent Street, Sydney.
Western	A. Eustace, 19, Ferndale Road, Northville, Bristol, 7.
West Wales Sub-Section	H. P. Sanderson, I.C.I. Ltd., (Metals Division) Waunarlwydd, near Swansea.
Wolverhampton	W. J. Marshall, Moston Park, Lee Brockhurst, Salop.
Yorkshire	J. L. Townend, 26, Moor Allerton Drive, Street Lane, Leeds, 7.

Graduate Section Honorary Secretaries

Birmingham	J. Thompson, 68, Glenpark Road, Washwood Heath, Birmingham, 8.
Coventry	S. Hey, 112, Moseley Avenue, Coventry.
Halifax	T. Marsden, 6, Kell Lane, Stump Cross, Halifax.
London	R. T. Mustard, 47, King's Road, Woodham, Weybridge, Surrey.
Luton	C. S. Brewer, 114, Hart Lane, Luton.
Manchester	W.R.Matley,58,Heyscroft Rd.,Withington,Manchester,20
North Eastern	G. D. Robinson, 188, Westgate Road, Newcastle, 4.
Wolverhampton	L. C. Jones, 1, Merridale Lane, Wolverhampton, Staffs.
Yorkshire	S. Metcalfe, "Marstan," 20, Heath Mount, Leeds, 11.

T. A. WESTALL, M.I.P.E.

Institution Personalities — 12.

T. A. WESTALL, M.I.P.E.

T. A. WESTALL, M.I.P.E.

Mr. Thomas A. Westall, Works Manager of Burco Engineering Company, Burnley, and President of the Preston Section of the Institution, can claim immense experience in the engineering industry, particularly in the sphere of production. Indeed, his chief interest has always been centred in this field, and he was one of the pioneer instructors of Production Engineering in Lancashire.

As early as 1915, he was lecturing on this subject at Burnley Municipal College, and 12 months later was in charge of the practical training of Engine Fitters of the Royal Flying Corps, for whom courses were arranged at the College. He continued for many years to lecture frequently at both Accrington and Burnley Technical Colleges, and during the Second World War was appointed lecturer, under the joint control of the Ministry of Labour and the Education Authority, for the training of foremen and supervisors.

Mr. Westall completed his apprenticeship with Simpson Brothers, of Hapton, in 1912, and from 1914/1918 was in control of tool design, tool-making and methods of manufacture for this firm. He then joined Howard and Bullough, Ltd., of Accrington, as a Jig and Tool Draughtsman and was subsequently appointed Draughtsman in charge of experimental and development work.

In 1929, he accepted an appointment with the Singer Manufacturing Company, Clydebank, as Assistant Superintendent, but in 1932 returned to Lancashire and joined the staff of Butterworth and Dickinson, Ltd., of Burnley, Textile Engineers, with whom he held respectively the positions of Production Engineer, Machine Shop Manager and Works Manager. Four years later he became Assistant Works Manager. In 1941, he joined Joseph Lucas, of Burnley, as Assistant Works Manager, and left this firm in 1943 to take up his present appointment.

Mr. Westall has always been keenly interested in any activity or organisation connected with Production Engineering, and was one of the first Associate Members on the formation of the Glasgow Section. On his return to Lancashire, he was attached to the Manchester Section until the inauguration of the Preston Section, when he was elected a member of the first Section Committee. He was elected a Member of Council in 1947, and took office as Section President in 1948.

INSTITUTION NOTES

June, 1949

NOTICE

At an Extraordinary General Meeting of the Institution held at 36, Portman Square, London, W.1 on Thursday, 28th April, 1949, at 4.0 p.m., the following SPECIAL RESOLUTION was carried:

Resolved "that the revised Articles of Association as circulated to all members of the Institution with the notice convening the meeting be and are hereby adopted as the Articles of Association of the Institution of Production Engineers."

(*signed*) C. B. THORNE,
Director and General Secretary.

NEW SUBSCRIPTION RATES At an Extraordinary General Meeting held at the Institution's Headquarters on Thursday, April 28th, 1949, a new scale of membership subscriptions was adopted as follows:

Members	£5 5 0
Associate Members	£4 4 0
Intermediate Associate Members	£3 3 0
Associates	£4 4 0
Graduates	£2 12 6
Students	£1 1 0
Affiliated Firms (*no change*)	£10 10 0
Life Membership	40 guineas

The new rate of subscription will come into force as from 1st July, 1949. Members who pay their subscriptions by Bankers' Orders are requested to notify their banks of the change at the earliest possible moment, in order to avoid the possibility of errors.

MEETING OF COUNCIL The next meeting of Council will be held on Thursday, July 21st, 1949, at 36, Portman Square, London, W.1.

I.P.E. EXAMINATION REQUIREMENTS At a meeting of Council held on 20th January, 1949, it was agreed that all candidates who completely satisfied the Graduateship Examination requirements, or gained complete exemption from them,

before 1st September, 1950, and are elected Graduates or make application for election before that date, may be deemed to have satisfied the examination requirements of the Institution in all respects.

When the time comes for their application for transfer to the grade of Associate Member, they may not be asked to undertake any other examination or part of an examination.

TECHNICAL STATE SCHOLARSHIPS, 1949

As announced by the Ministry of Education in Administrative Memorandum No. 319 of 19th April, 1949, Technical State Scholarships to the number of not more than 100 will be offered to Students from Technical Colleges and other Establishments for Further Education, to enable them to pursue full-time degree courses or courses of equivalent standard at Universities, University Colleges or Technical Colleges. The memorandum gives information concerning qualifications and conditions for entry, and full particulars concerning entry and method of application are given in an explanatory leaflet, Form 1 U.T.

Intending candidates may obtain copies of Form 1 U.T. and Application Form 2 U.T. from Principals of Establishments for Further Education, and applications must be submitted through Principals to reach the Ministry not later than 30th June, 1949.*

HIGHER NATIONAL CERTIFICATES IN PRODUCTION ENGINEERING

A pamphlet has been prepared by the Joint Committee for the Higher National Certificate in Production Engineering, giving information regarding courses, and containing a list of the colleges at which such courses are conducted.

Copies of this pamphlet may be obtained on application to the Head Office.

TECHNICAL EDUCATION

The Institution is interested to note this educational development in Australia—Certificate and Diploma Courses in Production Engineering have now been established by the Technical Education Branch, New South Wales. The Lecturer in Charge of Production Engineering is Mr. C. A. Gladman, B.Sc.(Eng.), A.C.G.I., M.I.P.E., A.M.I.Mech.E., M.I.E.D., and the Courses are offered at Sydney Technical College. This important development is characterised by two main courses in Production Engineering, both of five years' duration, but commencing at different levels of general education ; the following gives a very brief description concerning the nature of the Courses.

* This notice is of particular interest to candidates who have completed a course leading to an Ordinary National Certificate or Diploma, but before submitting applications advice should be obtained from Principals of Educational Establishments.

(a) *Certificate Course*—designed primarily as a basic course in Production Engineering, but opportunity is given in the final year (and subsequently by the medium of post-certificate courses) for specialised study in particular fields.

(b) *Diploma Course*—engendered by the growing need in Australia for Production Engineers of the highest qualifications to occupy major professional positions in the engineering industry. Students with the requisite ability enrolled in such a course are enabled to attain more rapidly the high standard and broad scope of knowledge demanded for such positions. A booklet entitled "Production Engineering" and giving full details and syllabuses of the Courses is issued by the Technical Education Branch, New South Wales.

EDUCATIONAL APPOINTMENTS

Merchant Venturers' Technical College, Bristol. Applications are invited for appointment as Lecturer in Production Engineering. A really suitable candidate would be appointed with Senior Assistant status—salary scale £700-£800 p.a. It is intended to develop a Higher National Certificate Course in Production Engineering and establish an experimental machine tool laboratory. The person appointed must be capable of undertaking the development of these provisions ab initio. Previous experience of teaching production engineering subjects and up-to-date industrial background essential. Further particulars may be obtained from the Registrar, Merchant Venturers' Technical College, Unity Street, Bristol, 1.

Wolverhampton & Staffs. Technical College. Applications are invited for the appointment of a full-time teacher for work mainly in connection with the Ordinary National Certificate in Mechanical Engineering and the Higher National Certificate in Production Engineering. The salary will be in accordance with the Burnham Scale, with additions for degree and recognised training. Further particulars may be obtained from the Clerk to the Governors, Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton.

UNIVERSITY OF DURHAM SCHOLARSHIP

It is widely recognised that the future well-being of this country depends on the steady influx of technically trained personnel into industry. A Company which has long maintained this fact, and has done much to give practical support to it, is The Power-Gas Corporation, Ltd., of Stockton-on-Tees. This support is shown in the announcement that this Company has endowed an Open Scholarship, tenable at Durham University, to enable suitably qualified students to undertake a course of study, leading to a degree, in either civil or

mechanical engineering. The Scholarship will normally be tenable for a period of three years, but in exceptional cases it may be extended for a fourth year.

In 1947, The Power-Gas Corporation endowed an Open Scholarship at the University of Leeds for gas, chemical, mechanical or civil engineering. Here again the Scholarship was tenable for a period of three years, with a possible extension for a fourth year.

BRITISH STANDARDS *Provisional British Standard Specification* 1391:1947—*Performance test for protective schemes embracing stoving paints used for the protection of light-gauge steel and wrought iron against corrosion.*

The Committee responsible for the drafting of the above provisional British Standard is anxious to obtain information from those who have used it regarding the reproducibility of the tests and its value in predicting service performance.

The Committee does not wish to issue a formal questionnaire but it will facilitate the correlation of information obtained from various sources, and ensure that the essential points are covered in each case, if the following questions could be borne in mind when replying :

1. For what purpose do you/have you/used B.S. 1391:1947 ?
2. Do you make much or little use of it ?
3. Does your experience lead you to believe that the results give a reasonable indication of the probable service behaviour of protective coatings covered by the specification ?
4. Have you encountered any difficulty in interpreting the results ?
5. Are you satisfied with the reproducibility of the test ?
6. Do you consider the test should be modified ? If so, how ?
7. Have you used this test on any other protective schemes than those specifically mentioned in the specification and with what results ?
8. Have you any other observations to make ?

Any information would be greatly appreciated and should be addressed to the Chairman of the Standards Committee at the Institution's headquarters.

NEWS OF MEMBERS

Mr. V. Ashton, A.M.I.P.E., has been appointed Senior Advisory Officer for the East and West Ridings, Yorkshire, to The Production Efficiency Service of the Board of Trade.

Mr. C. E. Barkworth, A.M.I.Mech.E., A.R.Ae.S., Grad.I.P.E., is now Chief Engineer of The Birtley Co. Ltd., Birtley, Co. Durham.

Mr. A. L. Beech, Int.A.M.I.P.E., is leaving the United Kingdom to take up an appointment as Superintendent of the Non-Ferrous Group to the Pakistan Ordnance Factories.

Captain R. Le Roy Garst, Int.A.M.I.P.E., has joined the Production Engineering staff of the Anglo-Iranian Oil Company in London.

Mr. Denis B. Melton, A.M.I.P.E., is now Assistant Works Manager to Auto-Klean Strainers, Ltd., Hounslow.

Mr. T. B. Prew, A.M.I.P.E., A.M.I.Mech.E., has been appointed Engineering Manager to the Engineering Division of Lotus, Ltd., Stafford.

Mr. Max Samuely, A.M.I.P.E., A.M.I.E.C., has emigrated to Canada, and has taken up the position of Tool Engineer in the Airbrake Division of Messrs. Westinghouse, Hamilton, Ontario.

Mr. H. Glynn Thomas, A.M.I.P.E., is now engaged as Technical Service Engineer in the Contracts Department of Davy and United Engineering Co., Ltd., Sheffield.

Mr. G. C. Twine, Grad.I.P.E., is now engaged as Planning Engineer to Diamond " H " Switches, Ltd., London.

Mr. W. Udall, A.M.I.P.E., A.M.I.Mech.E., Chief Engineer of the Brightside Foundry & Engineering Co. Ltd., Sheffield, has been appointed to the Board of their subsidiary firm, Buckley and Taylor, Ltd., Oldham.

OBITUARY

The Institution deeply regrets to announce the death of Mr. John Clare, M.I.P.E., a founder member of the Sheffield Section, and Honorary Secretary for fourteen years, until failing health compelled him to resign this office in June last year.

In his capacity of Sales Engineer for Craven Brothers (Manchester) Ltd., Mr. Clare was very well known and respected in the heavy machine tool world, and will be sincerely mourned by his many friends and colleagues.

The Institution has also learned, with great regret, of the death of Mr. Sidney H. Miller, A.I.P.E., London Director of Fletcher Miller, Ltd. Mr. Miller was a member of the Central Liberal Club and an Associate of the Institute of British Engineers, and his passing will prove a severe loss to his many friends in industry.

The Institution has suffered further loss by the recent death of Mr. E. P. Paxman, M.I.P.E., Managing Director of Davey Paxman & Co. Ltd., of Colchester ; and of Mr. F. R. Augier, Int.A.M.I.P.E., of the Calcutta Section.

BOOKS RECEIVED

" Elementary Mechanical Vibrations " by Austin H. Church (Professor of Mechanical Engineering, New York University). Sir Isaac Pitman & Sons, Ltd., London. Price 22s. 6d. net.

The author's treatment of a subject which is essentially mathematical is simple and direct. No abstruse mathematics appear in any part of the book and it is well suited to the requirements of the student and practical engineer. Worked-out examples are included in the text, and a number of problems with answers are given at the end of each chapter.

Chapters 5 and 6 containing sections on vibration isolation and the dynamic vibration absorber, and Chapter 10 on balancing will be of interest to production engineers and machine designers. A chapter dealing with methods of vibration measurement would be a useful addition to the book.

The presentation of the subject matter is excellent, a particularly good feature being the method of numbering the diagrams and equations.

" The Properties of Soft Solders and Soldered Joints " by J. McKeown, D.Sc., M.I.Mech.E., F.I.M., with a foreword by Dr. Harold Moore, O.B.E., D.Sc., F.I.M. British Non-Ferrous Metals Research Association, London. Price 17s. 6d.

This book, which is the Research Monograph No. 5 of the British Research Association, deals with the mass of research which took place during the war to find the best way of reducing the amount of tin in solder.

Those interested in the application of soldering to production will find that although this work commenced with the object of tin economy, it developed into a wide series of investigations into solder and soldered joint properties, and although the need to use the types of solder investigated on grounds of economy is no longer so pressing, this work will form an important addition to the field of information available on the properties of the more regular solders.

A. L. S., M.I.P.E.

" The Milling Machine " by P. S. Houghton. Crosby Lockwood & Son, Ltd., London. Price 18s. od. net.

This is a well-written book for advanced students.

W.C., M.I.P.E.

" Estimating Machining Times " by T. W. Gorgon. Machinery Publishing Co. Ltd., Brighton. Price 12s. 6d. net.

ISSUE OF JOURNAL TO NEW MEMBERS

Owing to the fact that output has to be adjusted to meet requirements, and in order to avoid carrying heavy stocks, it has been decided that the Journal will only be issued to new Members from the date they join the Institution.

IMPORTANT In order that the Journal may be despatched on time, it is essential that copy should reach the Head Office of the Institution not later than 40 days prior to the date of issue, which is the first of each month.

SECTION MEETINGS

The following meetings have been arranged to take place in June, 1949. Where full details are not given, these have not been received at the time of going to press.

June

11th LEICESTER SECTION. A conducted tour of the Water Works at Cropston, Leicester, has been arranged.

14th WOLVERHAMPTON GRADUATE SECTION. A lecture on "Aluminium Alloys and Their Fabrication," together with a film, will be presented by the Aluminium Development Association at the Wolverhampton and Staffordshire Technical College, at 7-15 p.m.

16th GLASGOW SECTION. A visit to L. Sterne & Co., Hillington Works has been arranged to commence at 7-30 p.m.

18th WOLVERHAMPTON SECTION. A visit to Dowty Equipment Ltd., Cheltenham, has been arranged.

ELECTION OF MEMBERS

MEETING OF COUNCIL, 28th APRIL, 1949

The following were elected to membership by Council :—

As Members :

R. N. Barton, F. A. Bird, M.B.E., J. E. Gaffney, R. E. Harrison, L. C. Holmes, R. G. Hutchinson, J. Irving, J. C. Kerr, P. G. Lamont, N. G. Lancaster, T. McCulloch, R. C. Paranjoti, H. F. Plaut, S. W. Perkins, C. W. Roberts, V. J. Sankey, A. Stappleton, H. Stephens.

As Associate Members :

R. J. Andrews, K. T. Austin, H. Balmer, J. E. Batley, B. K. Bhattacharjea, F. E. J. Blomfield, T. Bradley, B.E.M., S. Christie, A. W. F. Christy, A. E. Christison, D. Clarkson, C. Corcoran, F. W. Cracknell, G. N. Cross, V. Crowther, E. K. Darling, J. P. Dobbie, J. J. Dodgson, D. H. Downie, G. F. Durant, N. N. Engelhard, R. Entwhistle, L. F. Eve, E. T. Foulds, G. F. P. Fox, D. S. Gardner, F. R. Hardy-Dobney, J. D. Hayes, W. Hayes, L. A. Hitch, H. A. Hobrow, W. J. Holway, G. Hubble, T. P. Hunt, H. R. J. Knight, J. Knox, R. J. P. Kohry, E. C. Lillycrop, C. J. Linzell, E. B. Loewendahl, D. S. McCarthy, A. Miall-Allen, R. Mondy, Y. Morel, F. F. E. Mountifield, J. V. Murcott, K. S. K. Murthy, E. J. Newcomb, G. N. Newsome, D. S. Nicol, G. W. Oakes, D. L. Oates, T. F. Ormerod, C. Pal, C. G. E. Parrott, O. G. Parry, R. E. Patmore, H. C. R. Pegler, R. H. Pope, S. N. Popkin, J. Purcell, F. Ralphson, B. Riley, J. L. Rogers, M.B.E., F. W. Ross, J. D. Rowe, D. G. Scott-Maxwell, P. S. Sear, W. F. Sharpe, J. Shepherd, H. G. Silverston, N. W. Simpson, C. G. Smith, K. W. Smith, A. L. Snell, G. Spraggon, P. S. J. Starr, J. D. Summerskill, A. F. Tame, H. Tarrant, E. T. Tavendale, L. W. Taylor, R. J. Thomas, E. F. Thompson, R. Thomson, L. J. Tidmarsh, W. F. Toynbee, H. R. Turner, P. R. Valentine, F. H. Ward, R. G. Washbourne, J. Wigglesworth, R. B. Wilkinson, R. V. Willsher, J. J. Woodward, C. V. W. Young.

As Intermediate Associate Members :

V. A. Allibone, J. Baker, M. R. Barton, P. Basu, W. Brookes, N. Brooks, F. Brown, A. R. Cason, J. Crabb, B. C. Crocker, P. Colley, D. L. Davies, A. E. Dodson, A. Everson, H. N. Ferguson, T. P. Finn, N. S. Garcha, A. K. Haskins, C. Kennedy, J. Kinahan, E. Lee, G. R. Lightford, H. E. Manwaring, R. R. Marsh, J. H. McPherson, A. Mentis, T. D. Narracott, A. Nicholls, F. Pickering, C. C. Postill, S. Pratt, R. C. Renton, W. Rees, G. A. Rowley, H. E. Stacy, H. Stevens, J. Stone, L. A. Tillett, W. Watson, G. H. Wharton, W. J. White, L. Wright.

As Associates :

R. Cassels, M. Hamers, J. D. Hannington, D. A. G. Kelly, V. G. Parry.

As Graduates :

S. Anwaruddin, J. R. Ball, H. W. Barnes, R. A. Bartholomew, S. Basketts, G. E. Boast, R. A. Boast, J. W. Brennan, K. L. Brookfield, G. R. Burn, M. E. Clark, H. G. Clarke, D. Collier, R. J. Currie, P. F. Deadman, A. Eastwood, E. E. Eaton, G. El-Kareh, G. W. Fraser, P. H. Fredericks, R. E. Gardner, D. Goodman, R. W. Griffin, R. Harris, J. C. Higson, H. K. Keetley, R. J. Keetley, D. Kennedy, W. G. Key, A. H. Kynaston, A. J. Lawrance, G. Mandal, G. T. Marsh, G. W. Mason, D. McCorquodale, J. P. McQue, A. P. Morris, K. E.

Myatt, P. W. Nicholass, J. W. Oddey, B. N. Ojha, K. P. Palmer, L. R. Phillips, T. A. L. Pullan, R. G. Reid, N. Sherrington, M. Sondhi, K. E. Stainer, L. Swift, E. Thompson, H. Treppte, E. A. Triggs, C. A. G. Turner, G. R. Wieland, P. J. Willshire, F. Whitaker, E. H. Wootton, R. C. Worrall.

As Students :

D. W. Birchmore, D. Birrell, F. J. Brown, A. R. Byford, P. B. Chamberlain, R. K. Charlton, R. H. Clough, A. G. Coltman, W. G. Colman, J. G. Crofts, A. A. W. Dawkins, W. S. Elliot, A. Fisher, A. L. Foster, T. N. Francis, R. T. H. Gant, N. E. D. Humphrey, F. A. Kempton, P. J. Lewis, E. McAlpine, R. G. Mitchell, T. F. Mitcheson, K. M. Mote, E. R. Murray, H. K. Peaster, D. W. Perkins, A. M Pritchard, I. J. Rana, B. B. Saxena, J. B. Saxena, W. L. Seaman, R. A. Sharpe, P. H. Sturgess, A. Taylor, J. A. Taylor, M. H. Toms, J. A. Tydie, C. Varah, E. B. Walker, T. R. Walker, E. N. Wharton, A. R. Wilkes.

Affiliated Firms :	Change of Affiliate Representatives
Hoover, Ltd....	J. Powell
Howard & Bullough Ltd.	F. Foster
Joseph Lucas Ltd.	T. G. Woodward
Ferguson, Pailin Ltd.	R. A. Rowbottom
	W. Weston
Sternol Ltd.	P. D. George
Stuart & Turner Ltd.	W. H. Perrin
Venesta Ltd....	A. J. S. Shewan

TRANSFERS :

From Associate Member to Member :

R. D. Bibby, H. C. Blackford, J. V. Brown, J. W. H. Clarke, E. Garlick, A. R. Gow, S. Green, J. Lomax, J. J. Lowe, A. J. Lund, R. J. Schoeder, L. W. Smith, J. E. Strick, F. V. Waller, J. Wotherspoon.

From Associate to Member :

T. W. Fazakerley.

From Intermediate Associate Member to Associate Member :

R. H. F. Bone, H. C. Brock, J. W. E. Brown, S. H. Brown, J. L. Burbidge, C. E. Butterfield, W. J. Cakebread, J. C. Campbell, F. Clark, G. Clarke, P. Gavin, R. D. Gaskin, B. Greathead, A. S. Hesketh, A. W. Hill, E. Hoyland, R. A. J. Inns, A. R. Jupp, J. E. Lissaman, W. V. Mercer, G. McPherson, R. E. Mills, R. Mishra, J. Padgett, H. Powell, A. Rowden, S. P. Roy, G. W. Shotton, T. Shotton, C. E. Smith, A. J. Spreag, T. E. Stevenson, L. R. Surtees, G. A. Symons, W. J. J. Tucker, C. Walker, A. Williamson, H. M. Wylie.

From Graduate to Associate Member :

H. Aked, K. L. Bajaj, D. C. Boak, C. R. Brazier, E. S. Carter, R. C. Dobbs, A. Edels, W. T. H. Golding, D. F. M. Griffiths, J. F. Holman, K. L. Jackson, E. E. Jones, A. W. A. Kay, A. F. Lovatt, B. G. Mann, J. McLeman, W. D. Moore, A. J. Munro, R. Nelson, D. R. Parker, E. H. Proffitt, F. A. Rowley, W. S. Teale, N. A. Tope, J. W. Yen.

From Graduate to Intermediate Associate Member :

C. B. Bartlett, J. D. Duggan, S. G. Lane, A. J. Naylon, E. A. Wilkes.

FROM STUDENT TO GRADUATE:

J. P. Clapham, C. W. Cutler, R. A. Draves, W. M. Faulds, F. Gale, P. F. Gilson, G. A. T. Groombridge, P. E. Hare, A. J. P. Johnson, K. E. Johnson, I. Jones, R. C. A. Jones, J. R. H. Kilroy, W. T. Massey, C. S. Phillips, A. R. Pilkington, W. Pollard, C. F. Randall, M. J. Sargeaunt, A. G. Waters, J. E. Walford, H. F. Watts, T. B. Wilcox.

MANAGEMENT'S DEBT TO ENGINEERING

by Lt.-Col. L. URWICK, O.B.E., M.C., M.I.P.E.

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As you all know there has in recent years been a great accretion of interest in this country in the subject of industrial management. A President of the Board of Trade set up a committee under the chairmanship of a President of the Federation of British Industries to consider the possibility of a central Institute of Management. That Committee has reported and the first Council of a British Institute of Management has been appointed. A Minister of Education nominated a Committee on Education for Management. Its report was endorsed by virtually all the existing management institutions and adopted by the Ministry. Another group has set up an Administrative Staff College. In all directions there is a display of activity and a general curiosity about the subject, hitherto unprecedented.

Now when a field of study which has previously been the domain of a few technically-minded enthusiasts suddenly becomes popular, that is a very dangerous moment. It is dangerous for a variety of reasons and in a number of directions. All the little people, for instance, who, when the subject was unpopular, were only too anxious to testify to their indifference to it, suddenly discover that association with it may have advantages. They hasten to scramble on to the band waggon. Other branches of learning which have previously advertised their purity from taint of contamination with the outcast, hurry to explain that what they have been teaching was really this selfsame subject. The more commercially minded are quick to appreciate that here is a new skill which offers opportunities for exploitation. The fact that they possess neither training nor qualification is of little account. After all, human nature is very gullible, even when it is ostensibly engaged in business. The label on the bottle is infinitely more important than the analysis of the mixture. Vendors of proprietary nostrums earn incomes which make honest-to-goodness medical practice look merely silly.

EARLY EXPERIMENTS

All this is very human and natural. It has happened before. In the two decades before and after the turn of the century a small group of men in the United States, of whom Frederick Winslow Taylor was the leading spirit, had been experimenting with new methods of management,

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particularly time and methods study. The main railways lodged an application with the Interstate Commerce Commission for an increase of rates. This was opposed by the shippers of the Eastern seaboard who briefed a brilliant young Counsel, Louis D. Branders —the man who subsequently became Lord Chief Justice Branders of the Supreme Court. Branders determined to base his case on an assertion that the railways were inefficient and wasteful. If they would adopt modern methods of management, such as Taylor and his associates were developing, they could save very largely on their costs and the increase of rates to the consumer would be unnecessary.

Naturally the preparation of this argument involved many sessions with Taylor and some of his collaborators, notably H. L. Gantt. It was at one of these sessions, in Gantt's flat in New York, that Branders pointed out the need for some general label to identify the group of methods and practices which he wished to expound in court. After some discussion those present agreed unanimously on the term " Scientific Management." Taylor himself was not present at this particular meeting. But he accepted the decision and subsequently used the words as a description of his own philosophy and methods.

It may be noted however, that the term did not originate as a description of an idea. No one thought of the idea of " Scientific Management " as such and then proceeded to develop it. Attempts to put what Taylor and his colleagues were doing into words came later—much later. In the beginning there were only deeds, certain inventive and fertile young executives struggling with practical problems and experimenting with new ways of meeting them. In the earlier stages such exposition as they attempted was purely descriptive and factual, the kind of paper anyone might read to this society on a new kind of valve or a method of tooling a particular type of job. F. W. Taylor's own first paper to the American Society of Mechanical Engineers in 1893 was entitled " Notes on Belting," his second in 1895 was called " A Piece-Rate System." It was not until 1903 that he came fairly into the open on the managerial side with " Shop Management." His Presidential address in 1906, while it dealt with similar material was more technical in presentation. He called it " On the Art of Cutting Metals."

THE SCIENTIFIC APPROACH

Ultimately and towards the end of his life he came to a full realisation of how much was implicit in the central conception of attacking every kind of problem which arises in the conduct of an industrial undertaking in the scientific temper, and through the intellectual methodology developed in the physical sciences. He appreciated that this

mental approach, this philosophy, was fundamentally far the most important feature of his work. This conviction emerges clearly in his testimony before the special Committee of the House of Representatives to investigate the Taylor and other systems of Shop Management in 1912. Incidentally this testimony, seldom available in this country, has recently been reprinted by Harper and Brothers in a splendid volume entitled " Scientific Management " which contains Taylor's " Shop Management," his " Principles of Scientific Management " and his evidence. It should be in the possession of every student of the subject.

But this synthesising and focussing of the idea was the final step. All the initial steps were practical. And at the time when the term " Scientific Management " first became common currency, it was a whole collection of such practical experiments about which men were thinking. It is this fact which has caused so much misunderstanding both here and in America. Initially the term covered a series of concrete events, things which people could touch and see. And it is always much easier to explain the concrete than the abstract. But gradually it became clear in the mind of their originator that the concrete things were unimportant, mere methods and systems and apparatus, essentially ephemeral, the clutter of daily business which would pass, improved out of all knowledge by his successors. What would not pass was the dream, the way of thinking about management which had led to these concrete manifestations, had made him so fertile in inventing them.

It was part of the tragedy of his life—and it was in some respects a tragic life—that he was perpetually battling against the misconceptions born of his own success. The very things for which men praised him and gave him honour were, as he saw clearly, a smoke screen, blinding them to the real significance of what he was trying to say. The very phrase which had made him famous—his tomb bears the inscription " the father of Scientific Management "—had been coined to summarise and popularise these incidental things, a mere shot in a legal engagement. It was associated with them in the public mind. He spent the last years of his life, and had fewer than he might have had since he overspent them, in struggling to repair this mischief. The testimony which has been mentioned was the evidence of a man in agony, in agony to make his deeper meaning clear above the clatter of the incidentals . . .

" Scientific Management is not any efficiency device . . . nor is it any bunch or group of efficiency devices. It is not a new system of figuring costs ; it is not a new scheme of paying men ; it is not holding a stop-watch on a man and writing things down about him ; it is not time-study ; it is not motion-study nor an analysis of the movements of men ; it is not the printing and the ruling and the

unloading of a ton or two of blanks on a set of men and saying, ' Here's your system ; go to it.' It is not divided foremanship or functional foremanship ; it is not any of the devices which the average man calls to mind when scientific management is spoken of."

IMPRESSIVE EVIDENCE

But this was in the future when in 1910 his associates met in Gantt's flat to help Branders with his case. After the hearings had been proceeding for about two months, Branders suddenly introduced a group of eleven witnesses, engineers and managers, who testified one after another that the railways by introducing Scientific Management could increase wages and, at the same time, reduce costs. They included the heads of several plants which had been applying Taylor methods for some years, Dodge of the Luik Belt, Hathaway of the Tabor Manufacturing Company, Towne of Yale and Towne. Harrington Emerson expressed the considered opinion that the railways could save a million dollars a day.

The manner in which the evidence was given was even more impressive than the claims advanced. Roy Stannard Baker wrote in *The Atlantic Monthly* the following March :

" To those who heard this testimony there seemed at first something almost magical about the new idea ; but as one sober, hard-headed business man after another testified as to what had been actually accomplished in his plant, when it appeared that Scientific Management had been applied with extraordinary results to highly diversified industries, from steel plants to bleacheries and cotton mills, and including railroad repair shops, the spirit of incredulity changed to one of deep interest. Another factor in carrying conviction to the hearers was the extraordinary fervour and enthusiasm expressed by every man who testified. Theirs was the firm faith of apostles ; it was a philosophy which worked and they had figures to show it. ' This,' said Mr. Commissioner Lane to one of the witnesses, ' has become a sort of substitute for religion with you.' "*

In the upshot the Interstate Commerce Commission decided against the railroads, but mainly on the grounds that the nett earnings of the lines had been so liberal in the past, that they could afford to pay higher wages and still pay good dividends. The railroads entirely ignored Scientific Management in their defence. The Commission in its findings dismissed the subject with the remark that it was everywhere in an experimental stage and that it had not been shown that such methods could be introduced into railway operation to any considerable extent. But that the shot had gone

* Quoted F. B. Coply—" Frederick Winslow Taylor." V. i. p. 8.

home was clear from the interest taken in the subject in railroad journals and by railway officials in other publications. Trade Union opposition was undoubtedly strong. Some of Taylor's associates, when asked to reorganise certain railway repair shops, declined on the ground that their work would become the target of every union man on the line. The master mechanic of one of the leading eastern systems who had been applying Scientific Management with great success for some years was subpoenaed by the Congressional Committee in 1912. He denied in evidence that he had ever had anything to do with it. He justified his perjury to Taylor on several grounds which added up to that it was as much as his job was worth to confess publicly that he approved of scientific management. He was however, going on with the work but under another name.*

" How doth the busy little B
Improve the standard hour ?
Although it smells
The same, it sells
Best as another flower."

INCREASED PUBLIC INTEREST

But if the railways were indifferent or hostile, the public was not. The hearings attracted wide and and on the whole reasonable notice in the press. Almost overnight Scientific Management achieved nation-wide renown and Taylor was besieged with requests to speak and write. The Technology Division of the New York Public Library compiled a list of references to Scientific Management in 1917. Prior to 1895 no articles on management appeared in any of the technical journals other than the Transactions of the American Society of Mechanical Engineers. In 1911 the total number listed was 219. Efficiency Societies sprang up like mushrooms.

Taylor viewed this outburst of popular interest with considerable misgiving. In April 1911 he wrote to a friend :

" I am in entire agreement with you that before fall the woods will be full of quacks who are introducing Scientific Management, and they will be highly likely to give a black eye to the whole movement in many cases. However, enough of the good work will survive to make it continue, and within two or three years the manufacturers throughout the country will be pretty well alive to the necessity of getting first-class men to help them in their reorganisation."†

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* Letter from F. W. Taylor to L. P. Alford, A.S.M.E., Sub-Committee on Economic Administration, July 1912, quoted Copley ii : pp. 374 and 375.

† Quoted Copley V. ii. p. 388.

To a manufacturer who complained to him that he had been imposed upon by an " efficiency engineer " he wrote :

" I am not at all surprised at the experience you had in the application of Scientific Management. About 99 out of every 100 men who have taken up the profession of introducing Scientific Management are either plain fakers or men who are merely in the business for the money they can get out of it. There are exceedingly few men who have had the large range of experience necessary to make a substantial success of this work."*

That is the main danger of a sudden outburst of enthusiasm for a technical subject, that its standards will be debased, that all kinds of nonsense will be dressed up as Scientific Management which is nothing of the kind. It has happened before. It may well happen in this country.

THE SECRET OF TAYLOR'S INFLUENCE

It is therefore a moment when it behoves all of us who care for genuine work to take stock, to remember the rock from which we were hewn. Which brings us back to Taylor's dream, to what he really meant by Scientific Management. How did it come about that this man towered above his fellows, that he set in motion ideas about the organisation of production which have revolutionised the methods of thousands of factories whose managers have never heard of his name ?

The answer seems to be that he possessed in rather an exceptional degree several qualities not usually found in combination.

His parents were both of Puritan and Quaker stock fired with the spirit of enquiry and independence ; his father was a man of an exceptionally gentle spirit, while his mother was a woman of great force of character. They lived a highly intellectual life, and Taylor's childhood brought him into contact with two wars, the American Civil War and the outbreak of the Franco-Prussian war which occurred while he was travelling in Europe. He was originally intended for the law and matriculated at Harvard, but trouble with his eyesight inhibited academic work for a period. He apprenticed himself as a pattern maker and machinist with a small engineering firm in Philadelphia.

At the moment when he was out of his time a business crisis was raging. He took a job as an ordinary labourer with the Midvale Steel Company. Within a few weeks he was made clerk of the shop and, after he had trained a successor, was put on a lathe. In less than 12 months he was made gang-boss (charge hand) of the lathe workers. In a few short years he became successively foreman of the machine shop, master mechanic in charge of repairs and chief

* Copley, i. p. 149.

draughtsman and chief engineer. Despite this phenomenal advancement, from labourer to a principal executive between 22 and 28, he also found time to take his M.Sc. in Engineering at the Stevens Institute entirely by night work, to win the United States Lawn Tennis Men's Doubles, to do a considerable amount of amateur acting and to get married.

Only a person of dynamic temperament could have covered such a programme. While he was never much interested in formal religion, his parents' spirit of enquiry came out strongly in his make-up in a passion for verification. And their earnestness of purpose repeated itself in a very acute sense of social responsibility. As his biographer has put it, he inherited " a whale of a New England conscience." Further he had a profound belief in control, starting with himself. Not only did he never drink or smoke : even tea and coffee were taboo.

All that sounds like a humourless, self-righteous prig. Far from it. Obviously he was full of fun. He was just one of those people for whom social differences don't exist. He was incapable of regarding any man or woman in any other light than as an individual human being, much like himself. But the fact that he considered that control was good for himself meant that he also considered it good for others—not his personal control, his whim, but the control of law when the right law had been discovered scientifically.

His passion for verification combined with his social conscience to make it difficult for him to realise that there was any reason why what was discovered as true should not be applied.

A DUAL PERSONALITY

These pairs of qualities, his interest in scientific truth and his father's gentleness on the one hand, his social conscience and his mother's imperiousness on the other, undoubtedly pulled him two ways and made him difficult to understand. It is so much easier to tie labels to people and to pop them into convenient categories. But here was a creature who didn't fit any of the compartments. One half of his nature was that of the scientific research worker, modest, reclusive. The other was that of the dynamic executive, energetic, forceful, determined to get things done, not for himself but because it was his plain duty to the community. It has been said of him that " he was so much more of an engineer than an executive that when serving as an executive he seemed always in danger of reverting to the pure engineer."*

He himself was aware of these conflicting elements in his make-up. In a letter to a friend in 1910 he wrote : " You will probably

* Quoted Copley i., p. 130.

realise that with me investigation, or rather invention, is a mental dissipation ; that it is a very great amusement, rather than a labour ; and that if I followed my personal inclination, I would be very likely to give the greater part of my time to this sort of thing. I realise, however, that no man has the right to do very much of this kind of work."* And how clearly that Pilgrim ancestry rings through those sentences. One can hear the echo of that Kenelm Winslow who landed from the Mayflower at Salem in Massachusetts 280 years before. He came from Droitwich in Worcestershire so being a Worcestershire lad myself, I won't say more. And there's another echo of his remarkable great-grandmother, Comfort Hussey. She was a famous Quaker preacher who thought nothing of riding alone from Portland, Maine, to Newport, Rhode Island, through a primitive New England, speaking at meetings of the Friends—forceful, gifted, and self-reliant.

Because he was brilliant as an investigator and research worker, there were those only too ready to suggest that he was indifferent as a manager. The answer was supplied by one of his colleagues at Midvale who said roundly,

" Fred Taylor not a good manager ! That is one of the most ridiculous things I have ever heard. Why, that boy as a manager was simply a wonder. He had a marvellous flow of language. He couldn't talk fast enough to get the ideas out of his head. And the way he adapted his talk to the intelligence of the man he was addressing was nothing short of exquisite. If a man had only a spark of pride, Fred Taylor would fan it into a roaring fire. Why, he would have filled up a corpse with enthusiasm if only the corpse could hear."†

Now if it wasn't any of the " devices which men usually call to mind when scientific management is spoken of " which was at the heart of his work, what was it ? Why among the most intelligent industrialists of his day were there men who treated what they were trying to do with his help as " a sort of substitute for religion " ? Why did a Roy Stannard Baker or a Branders, men of the highest distinction in alien fields, warm to him like a brother ? Why among many able and eminent engineers, Gantt, Gilbreth, Barth, Harrington Emerson and others who were associated with him or working on similar lines, did he stand out head and shoulders, was admitted by all of them as the acknowledged leader ? Why, to give the reverse of the same picture, did this dynamic executive who never treated any working man except as a friend and a brother, who

* Quoted Copley p. 171.

† Quotations from Helen Wadell, " The Wandering Scholars."

never had the shadow of a strike in any plant where he personally was operating, find himself the target of one of the bitterest personal compaigns ever waged by Trade Unionism in the United States?

A DIFFICULT ANALYSIS To penetrate the secret of greatness is never easy. Now that Fred Taylor "belongs to the ages" and the dust of controversy no longer obscures our vision, it is perhaps not extravagant to trace some parallel between his life and that of a genius of an earlier age—the great religious intellectual, Peter Abelard, "one of the makers of life, and perhaps the most powerful, in twelfth century Europe."* He too stood for truth as he saw it. "He was the magnet that drew all men," to the University of Paris, "in the years when 'Rhinoceros indomitus' lifted up his horn on Mont St. Genieviéve and the schools became a bull ring, where opponent after opponent tosses on the horns of his deadly logic."* He too was persecuted by the more conventionally minded of his contemporaries who found new truths unpalatable. But when at last he died in the great Abbey of Cluny, the Abbot, Peter the Venerable, "an austere man, a stern disciplinarian of his order" stood "abashed before the mystery of this man's life whom the love of God and the hate of men had broken."* He was a heretic, hounded by two Councils. Yet this great ecclesiastic wrote of his end "with a sort of heartbroken passion of reverence."* "His personality, no less than his claim for reason against authority was an enfranchisement of the human mind."*

It may seem a far cry from mediaeval Paris to Midvale and the Bethlehem Steel Works and Taylor's lovely home outside Philadelphia. But as Sir Richard Livingstone has reminded us "in every age the strongest force fills the common eye and distorts the common judgment."† In the middle ages it was religion. In our century it is science. And it was Taylor's great contribution to our time and to all time, to show how the methods of science could be carried over from purely material and technical things, to the much greater problem of how to organise our society so that the discoveries of the physical sciences do not overwhelm us. Herbert Spencer once wrote "Socially, as well as individually, organisation is indispensable to growth; beyond a certain point there cannot be further growth without further organisation." Can anyone doubt that at the end of the nineteenth century man's power to control material things had outgrown his knowledge of how to organise his societies so that they could live on terms with steam and electricity?

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* Quotations from Helen Wadell, "The Wandering Scholars."

† "Education for a World Adrift," p. 162.

Certainly after two world wars within thirty years no one will doubt it to-day. Taylor was the first man to show us how to begin to tackle that problem to suggest a gleam of hope.

BREAKING FRESH GROUND

He did so fundamentally because he was a first-class engineer, because he extended the strict scientific method in which he had been trained as an engineer, to a group of problems to which no one had ever applied that kind of thinking before. As he put it himself, " When men, whose education has given them the habit of generalising and everywhere looking for laws, find themselves confronted with a multitude of problems, such as exist in every trade, and which have a great similarity one to another, it is inevitable that they should try to gather these problems into logical groups, and then search for some general laws or rules to guide them in their solution."*

He was not content to treat management any longer as an accident, something which the individual ' picked up ' empirically merely by the experience with which he happened to make personal contact. Some 400 years before the first makers of modern surgery had similarly determined that no future surgeons should be allowed to operate on their screaming victims in the light of such skill as they could acquire by being apprenticed to a barber.

Naturally the first difficulty was to convince his fellow engineers that an extension of their outlook, or rather the transfer of their mental training, from their purely technical work to the managerial tasks which they were attempting, was any part of their business. Here, however, he was not alone. As early as 1881, the year after the foundation of the Society, Oberlin Smith of the Ferracute Machine Company read a paper to the American Society of Mechanical Engineers on the " Nomenclature of Machine Details."† This was a study of a standardised method of classifying machines and parts on the principle of " each object to have but one name and each name to belong to but one object." It also suggested a system of letter and number symbols which showed large economies over the methods of description then in use and greatly simplified identification and search. An engineer was beginning to look at a management problem. His first paper was reproduced in the first book on management published in this country . . . " Factory Accounts " by Garcke and Fells which appeared in 1887. The two authors were an engineer and an accountant.

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* " The Principles of Scientific Management."

† Oberlin Smith contributed a second paper in 1884 entitled " Topography of Machines."

OTHER IMPORTANT FACTORS

The tendency towards some exchange of experience between the engineering and commercial departments of factories was another and important influence. Point was given to it by a paper read to the A.S.M.E. in 1886 by Henry R. Towne of the Yale and Towne Manufacturing Company. It was called "The Engineer as an Economist." This was a frank appeal to the technically trained engineer not to isolate himself in his technique. He was part of a business. It was up to him to concern himself in the financial and profit-making aspects of management. It was in the year of Towne's paper that Taylor became a member of the A.S.M.E. They became firm friends, and Yale and Towne developed into one of the best-known plants operating under the Taylor system.

A third factor of considerable importance was the interest shown by engineers in methods of remuneration. Socially minded employers and managers on both sides of the Atlantic were concerned at the tendency of industrialisation to split society into warring classes. They recognised that a modern factory can only be really effective if there is unity of purpose among *all* those working in it. In the 1880's there was a great deal of optimism about the use of schemes of profit-sharing as a solution to this problem. But a large proportion of such schemes failed. As is increasingly recognised to-day, an intention on the part of the employer to give a "fair deal" to the workers in an individual factory in terms of money, while it is an essential fore-condition of collaboration, is usually not in itself the whole answer.

Both in Great Britain and in the United States there was a determined attempt to develop alternative means of convincing workers that exceptional effort on their part would receive its direct and legitimate acknowledgment in the wage packet. It was generally acknowledged that straight piece-rates were too liable to rate-cutting on the employer's side and quality cutting on the workers' side to provide an answer which was wholly satisfactory.

A series of papers was delivered to the American Society of Mechanical Engineers on this subject. William Kent in 1887 wrote on "A Problem of Profit Sharing." This was followed by "Gain Sharing" by Henry R. Towne in 1889 and F. A. Halsey's famous "A Premium Plan for Paying Labour" in 1891. It was from this angle that Taylor first approached the management problem. This should never be forgotten. When he was appointed charge-hand of the lathe-workers at Midvale he determined to put an end to the ca'canny which he knew to be rife in the shop. He tried to do so by the usual disciplinary methods customary in the American machine shops of the eighties. There followed a three years' struggle with the men. Taylor was supported by the management and won through.

"A FAIR DAY'S WORK"

But this young (he was only 24 or so), sensitive, friendly, democratic person was heart-sick at the brutalities of the conflict. The men were his friends. And yet to get an output which he knew to be reasonable and easily attainable he had to curse and threaten and fire through these long years. Analysing the problem, he came to the conclusion that what was really wrong was that both sides were arguing about an abstract idea which they called " a fair day's work " without the least notion of what, in concrete terms, they meant by the phrase. Neither management nor men had the foggiest idea of how many units of output in any process did in fact constitute " a fair day's work." If a means could be found of measuring this abstraction objectively, so that both sides knew what they meant, so that they were arguing about something specific, then they might eliminate much of the bitterness. It was " the engineering approach " to a social problem—for Heaven's sake let us be factual, let us argue about something concrete which we can measure, not about a phrase which has no foundation in reality, only a misty surcharge of emotions.

He set up an experimental lathe in a corner of the shop and started out to take measurements, to determine precisely what was " a fair day's work." Of course, he inadvertently discovered two things :

(a) That in addition to the effort exerted by the worker there were a multiplicity of factors affecting output, planning of work, flow of material, speed and condition of machines and so on, which were the responsibility of management.

(b) That the methods adopted by different workers to do the same operation were entirely unstandardised, and that workers expended a tremendous amount of time in experimenting or guessing as to the best way to do a job. In other words what is called " skill " is a generalised acquaintance with the tools and processes of a particular industry, or of a particular operation within an industry. But in modern industry, where the same process is repeated countless times, the actual details of that process can be studied under laboratory conditions and precise instructions laid down as to the best way of carrying it out. Only this research cannot, of course, be carried out by the individual worker for himself. It must be done for him by the management. And the worker must be persuaded to follow the detailed instructions exactly.

From these two general conclusions flowed the whole of the developments called " scientific management." It was concerned with so arranging the work of management that every possible handicap to production was swept away and so organising the worker's task that he could achieve a high standard of output

without fatigue. It was, of course, the transfer of " skill " from the individual worker to management under the second head which was at the root of the trade union opposition to scientific management. After all, the workers regarded their relation with management at that time purely as a bargaining relation in which the " skill " of the individual worker was the best card in their hand. If this was to be transferred to the management they would be in the position of a man playing cards with an opponent on condition that any trumps should be transferred to the opponent.

THE PIECE-RATE SYSTEM

On the basis of his experiments Taylor wrote a further paper for the American Society of Mechanical Engineers in 1895 entitled " A Piece-Rate System," which described his differential piece-rate under which the worker was paid a high rate for following the prescribed instructions and achieving standard and a very much lower rate if his total performance fell short. He tried to make it clear that the heart of the idea was the analytic fixing of rates by time-study. But generally the paper was regarded primarily as merely another variant on the different incentive schemes which had been put forward. The basic difference was of course that in normal incentive schemes the emphasis is on the positive effect of the money stimulus in spurring the worker to do as much output as possible. In Taylor's scheme the emphasis was not on the money stimulus at all. The effect of the high rate was indirect ; it was merely a reward to the worker for doing exactly what he was told. The effect of the lower rate was negative ; it was a penalty for departure from standard. The emphasis was on management's responsibility for working out scientifically the best way of doing the job. If that was done properly the output came automatically without any extra effort on the worker's part.

Simultaneously but separately Captain Henry Metcalfe of the Frankford Arsenal, U.S. Navy, had been working out a complete system of shop returns. He contributed a paper to the proceedings of the A.S.M.E. in the same year as Towne's " The Engineer as an Economist " ; it was called " The Shop Order System of Accounts." One of Taylor's most attractive traits was his open-mindedness and generosity to other workers in the same field. When in 1903 he really tried to summarise his work in his famous paper " Shop Management " he bewailed the lack of any " school of management " so that " the finest developments are for the most part isolated, and in many cases almost buried."

Of Metcalfe's work he wrote " The card system of shop returns invented as a complete system by Captain Henry Metcalfe . . . represents another distinct advance in the art of management . . . The writer . . . was at the same time engaged in the slow evolution

of a similar system in the Midvale Steel Works, which, however, was the result of a gradual development instead of a complete, well thought-out invention as was that of Captain Metcalfe."* He also mentioned by name six other people with appreciative reference to particular work they had developed.

INFLUENCE THROUGH THE A.S.M.E.

In 1906 Taylor was elected President of the American Society of Mechanical Engineers. Instead of the usual presidential address he delivered his famous paper " On the Art of Cutting Metals." In the discussion of this paper, Henry R. Towne, himself a past-President, said, " The art of forming and tempering metal tools undoubtedly is coeval with the passing of the stone age, and therefore, in antiquity is at least as old, if it does not outrank the arts of sewing and writing. Like them it has remained almost unchanged from the beginning until nearly the present time. The work of Mr. Taylor and his associates has lifted it at once from the plane of empiricism and tradition to the high level of modern science, and apparently had gone far to reduce it almost to an exact science. In no other field of original research, that I can recall, has investigation, starting from so low a point, attained so high a level as the result of a single continued effort."†

Thus, in the years between 1881 and 1906 a new branch of human knowledge had been carved out of chaos. And the great bulk of the pioneer work was done by a small group of members of the American Society of Mechanical Engineers—Towne, Dodge, Gantt, Barth, Metcalfe, Hathaway and some others. To a man they looked to Fred Taylor as their leader and source of inspiration. For the first fifteen years of this period the Society was the forcing ground. Of 17 references to management subjects between 1881 and 1891, nine appear in its proceedings. After that date the technical magazines began to carry more articles on the subject. Between 1891 and 1901 there was a considerable interchange of American and British experience.

From 1900 onwards the technical press carried a substantial bibliography. After the Eastern Rates Case in 1910 articles on management flooded the popular magazines. But for Taylor and the A.S.M.E., 1906 was the high-watermark. Up to that point a few but influential members of the Society had been genuinely enthusiastic. But as management made headway a counter-movement began. Efforts were made to discredit Taylor and his work. " Not an open movement, just a quiet and decent choking off, and a subtle discouragement of papers on management. If

* " Shop Management," p. 202.

† Foreword to " Shop Management," p. 9.

the Society limited its discussions to such safe and sane subjects as gas engines all would be well."* The effect was marked. Taylor's last paper "The Principles of Scientific Management," was shelved so long by the Meetings Committee in 1912 that eventually he published it elsewhere. Between 1906 and 1911 only seven more papers on management are listed by the Society, but there were 391 in the regular engineering magazines. Thus the A.S.M.E.'s share in this period was only some 1.75% as compared with over 50% in the preceding 15 years.

TRADE UNION AGITATION

Much of the hostility was no doubt innocent enough. It derived from fear of his personality and jealousy of the devotion he inspired—the kind of thing that is common form in professional and democratic institutions. There were professors who were exasperated to find a practical man invoking the sacred name of science. Some of it was more sinister. Engineers representing great corporations found it dangerous to conceive of management as subject to "laws." Taylor's ethical outlook was more than they could stomach. There was a very real fear of the tremendous feeling excited by the Trade Union agitation against Scientific Management—some of it not far removed from downright moral cowardice. Taylor's last years—he died in 1915—cannot always have been very happy. That, however, is in the past. In 1920 the Society established a Management division. Two years later its membership exceeded that of any other of the Society's professional divisions and, to the best of my knowledge, has remained in that position ever since. That is the memorial Taylor would have wished for, that and the recognition that management was fundamentally the child of engineering.

That last point has a special significance for our problems here in Great Britain to-day. I am back to where I started from. When a subject becomes popular, that is its dangerous moment, that is the moment to look to its origins and hold firmly to them.

When Taylor in his testimony before the Committee of Investigation tried to state positively what Scientific Management is, he was reduced to a very simple statement . . . "In its essence scientific management involves two conditions . . . Both sides must take their eyes off the division of the surplus as the all important matter, and together turn their attention towards increasing the size of the surplus . . . Both sides must recognise as essential the substitution of exact scientific investigation and knowledge for the old individual judgment or opinion . . . in all matters relating to the work done in the establishment." Just those two things. You must have a common purpose before you can expect to co-operate

* Copley, ii. p. 251.

at all : that's why Taylor started his experiments. The men weren't co-operating. To find out how to do this you must have truth—technical, exact, objective knowledge.

It has been charged against scientific management that it is hard, inhuman. That is rank balderdash. Taylor was one of the most human men who ever lived. His whole life work started from his detestation of a situation in which he had to treat men rough. He *had* to find a better way. And the way he found was the engineering way, the scientific way. Get the facts, and all else shall be added unto you. Let us remember those two things. Scientific management *is* concerned with the human element, the dynamics of management. Unless and until there is a common purpose, the will to co-operate, it cannot exist. Secondly, the way to such a common purpose is the engineering way, respect for truth, absolute scientific integrity. If we can we shall walk dryshod on the troubled waters of popularity. In Taylor's words " enough of the good work will survive to make it continue."

FABRICATION AS APPLIED TO LIGHT AND MEDIUM SIZED COMPONENTS

by R. M. WATTS.

Presented to the Coventry Section of the Institution, November 12th, 1948.

Because of the wide scope of a subject of this character, the talk has been divided into three sections covered by the following sub-headings :

(1) A brief outline of the different methods of welding as on fabricated work.

(2) Fabrication by welding as an alternative to casting or riveted constructions.

(3) Manufacturing suggestions including tooling and methods of reducing distortion to the minimum.

TRAINING AND POLICY

Before describing the different methods of welding it should be recognised by all would-be users that welding is a highly scientific process, and that the true welder is a man who should in the first instance have received proper training. If welding is to be introduced as a new method of construction or to supplement an existing method of production, it should be introduced by the executive management who should satisfy themselves of the wisdom of the new policy by analysing carefully the following points :

(a) The cost of the process.

(b) Suitability of the material to be used.

(c) Preparation of material prior to the welding process.

(d) The most suitable process of welding to adopt.

(e) The type of plant and equipment.

(f) The economical layout of the Welding Department.

There must essentially be provision of skilled personnel to design the welded product, to organise, supervise and execute the work efficiently and the management would be well advised to examine carefully the merits of each system of welding as being applicable to the production of their particular product.

The different processes can be illustrated in the form of a family tree in which welding is divided into two main sections, (a) fusion welding and (b) resistance welding, each having its particular use in fabricated work. It is not intended in this talk to go into the technical aspects of welding but rather to give a good idea of the different processes and the functions they perform.

Fusion Welding, as its name implies, relies on heating to a fluid state the edges of the pieces to be welded and allowing the metals to flow together without any pressure being applied.

Resistance Welding means to heat electrically the parts to be welded and then forging them together when in a plastic state by mechanical means, i.e. springs or pressure hydraulically or pneumatically applied by either manual or automatic methods.

In regard to fusion welding, it is perhaps advisable to mention the temperature of the various methods of welding, as these affect considerably the question of distortion which will be discussed later :

Electric Arc — 5300°C. approx.

Oxygen acetylene — 2997°C. approx.

Atomic Hydrogen — 3757°C. approx.

ARC WELDING

The process of arc welding may be described as a non-pressure welding process wherein the welding heat is obtained from an arc struck either between the base metal or weld metal and an electrode, or between two electrodes. It is generally considered to be the cheapest and most efficient of all the fusion welds, that is, providing that a comparison is possible, and due to the heat being localised less distortion is noticeable. Cheaper operating costs and faster speeds are also achieved. Arc welding is generally applied to materials of $\frac{1}{8}$ in. thickness or over but it can in certain circumstances go down to $\frac{1}{32}$ in. given controlled conditions.

ATOMIC HYDROGEN WELDING

Very briefly, this process employs an alternating current in conjunction with a stream of hydrogen gas. The arc is maintained between two small tungsten electrodes through which a stream of hydrogen gas is directed and is manipulated in a similar manner to the gas blowpipe flame whilst the weld is effected with or without filler metal.

The temperature of the atomic hydrogen arc is very high and capable of easily melting metals which hitherto were considered impossible to weld. The hydrogen in addition to providing the high temperature reaction also provides a highly reducing atmosphere which effectively covers the weld and the electrode. Welds made by this process are exceptionally ductile and neat in appearance, whilst the loss of alloying elements in the parent metal and the weld metal deposited from a filler rod is reduced to a minimum. Due to high rate of welding, less heat is distributed into the weld, and consequently less distortion is found than in oxy-acetylene welding.

It can be used satisfactorily on the welding of light gauge sheets

up to 10 SWG and also for the depositing of tool steel on press tools and for the repair of cutting tools, e.g. shanks of drills, reamers, collets, etc.

OXY-ACETYLENE WELDING

Oxy-acetylene welding whilst having its particular uses in engineering is nevertheless expensive, distortion is greater and the process is relatively slow in operation, and should not be used if any of the other processes can be adopted.

The initial cost of the equipment is low and for that reason may be used in preference to the more expensive electric arc or atomic hydrogen processes, but should be restricted to a maximum of $\frac{1}{4}$ in. thick. Particular care should be exercised in connection with the preparation of joints, and parts differing in thickness are best avoided if a re-design can be made to the joint.

Oxy-acetylene welding finds its true field of application on sheet metal work, intricate ferrous and non-ferrous casting repairs, for welding the low melting point alloys and in motor car repair garages.

With regard to the resistance welding process, the full advantages to be gained have not yet been fully recognised by the industry ; experience has shown that the initial cost of the equipment is quickly recovered by the increased output and cheapness of manufacture.

DIFFERENCE BETWEEN FUSION AND RESISTANCE

In fusion welding the edges to be formed are melted and either allowed to run into each other to solidify on cooling or are joined by the addition of molten filler material, heat being supplied by an oxy-acetylene blowpipe, atomic hydrogen torch or by an electrode holder.

An important point to note is that the molten metal solidifies without being subjected to pressure or mechanical work, and has therefore a *cast* structure.

In blacksmith's welding two components are heated to the plastic zone and then hammered together ; crystal growth occurs across the surfaces, and the joint having been subjected to hot work has a forged structure of greater ductility than the cast structure obtained by fusion methods.

Resistance welding is a similar process except that the heat is supplied by passing a heavy electric current through the components, the pressure being applied through the electrodes carrying the current.

The four main types of resistance are :—

(1) Spot (2) Seam (3) Projection (4) Butt.

SPOT WELDING Described very briefly, spot welding replaces riveting on the thinner materials, its advantages being lower manufacturing costs, greater strength, and no danger of working loose when subjected to vibration.

SEAM WELDING This process is similar to spot welding except that the electrodes are in the form of wheels between which the sheets to be joined are passed ; and as these wheels rotate, intermittent pulses of current are fed through them and a series of overlapping welds are formed making a fluid tight joint.

PROJECTION WELDING A modern development of spot welding, and by this method up to four or more welds can be made simultaneously by using small projections pressed out on one component and welding between flat electrodes covering the total area of projection.

In the fabrication of light metal assemblies this method is proving very low in cost and quite efficient, besides having the advantage of a perfectly clean and flat face, without any signs of deformation.

BUTT WELDING This method enables end to end or edge to edge joints to be welded from the lightest gauge up to materials having a cross sectional area of 10 square inches or over. To summarise, in resistance welding an electric current is passed through a joint, generating heat only where needed as it encounters resistance between mating surfaces ; the process encounters heat accurately in amount and location and for tasks to which it is applicable, resistance welding offers one or more of the following advantages : faster welding, easier fabrication, less distortion, simpler operation and economy of materials.

SUITABLE MATERIALS Most metals or combination of metals commonly welded in industry by any other method can be resistance welded, as shown in the chart on the next page.

In addition certain metals extremely difficult to weld in any other way can be readily joined by this process, its application varying from delicate parts such as radio tube filaments to ponderous products such as railroad cars etc.

COMPARISON BETWEEN CASTINGS AND WELDINGS Having discussed very briefly the various major welding processes the time is now opportune to discuss the important comparison as to whether welding fabrication is more economical than castings or riveted constructions.

Cast iron as one of the major materials of construction held for many years pride of place in the world of industry, but with the inception and development of the process of arc-welding its partial eclipse was in many cases inevitable.

	Aluminium	Stainless	Brass	Copper	Galvd. Iron	Steel	Lead	Monel	Nickel	Nichrome	Tinplate	Zinc	Phos. Bronze	Nickel Silver	Ternplate
Aluminium	×											×	×		
Stainless		×	×	×	×	×		×	×	×	×		×	×	×
Brass		×	×	×	×	×		×	×	×	×	×	×	×	×
Copper		×	×	×	×	×		×	×	×	×	×	×	×	×
Galvd. Iron		×	×	×	×	×	×	×	×	×	×		×	×	×
Steel		×	×	×	×	×		×	×	×	×		×	×	×
Lead							×				×	×		×	×
Monel		×	×	×	×	×		×	×	×	×		×	×	×
Nickel		×	×	×	×	×		×	×	×	×		×	×	×
Nichrome		×	×	×	×	×		×	×	×	×		×	×	×
Tinplate	×	×	×	×	×	×	×	×	×	×	×		×	×	×
Zinc	×			×	×			×				×			
Phos. Bronze ...	...	×	×	×	×	×		×	×	×	×		×	×	×
Nickel Silver ...		×	×	×	×	×	×	×	×	×	×		×	×	×
Ternplate		×	×	×	×	×	×	×	×	×	×		×	×	×

(Reproduced from the " Machinist " 7th December, 1946.)

For the first time the designer was in a position to utilise a basis structure consisting of the barest essentials and to reinforce this directly where requisite without regard to process limitations.

Such complexities as coring and extraction from the mould, which are ever present in designs based on foundry practice, can be disregarded in the replacement of castings by weldings. It will be appreciated that a comparison between two or three such important manufacturing processes must essentially be of an ambiguous character, and although many sensible arguments can be put forward to substantiate a claim in either direction it is up to the designer, engineer, draughtsman or process engineer to analyse correctly each process before deciding on a final design.

Another important point is that in making a comparison, great care should be exercised in avoiding unfair competition between the two main processes and it is an established fact, particularly in factories where both processes are carried out, for the engineer in charge to be biased one way or the other to the detriment of the job concerned and to the firm he represents and so long as we appreciate that there is a place in engineering for each process, so can we fairly assess the correct one to use. The term fabrication is generally very loosely applied, because the meaning of the word is to construct or form by manufacture, so whilst it is obvious that this term can apply to many forms of manufacture, besides welding, I propose to refer to fabrication by welding as " weldings," as distinct from " castings." Therefore fabrication by welding means to construct from raw materials such items as bars, angles, channels, beams, plates etc., and weld together in such a manner as to form the required structure.

Dealing first with the advantages of castings over weldings these can be classified under the following headings :—

(1) *Advantages of a self lubricating material.* Cast iron holds an advantage over mild steel when it is necessary to have a number of bearing surfaces such as may be found in machine tools, etc., i.e., lathes, planing, shaping and milling machines which if made as weldings would involve a large amount of labour and material in forming a suitable working face.

(2) *For compressional strength and stability.* It is generally accepted that where stability and compressional strength are required as is found in presses, grinding machines, drop stamps, steam hammers and the like, cast iron is to be preferred generally to welding. Great strides have been made in recent years in popularising the use of weldings in the machine tool industry, but up to now it is generally confined to brake presses, guillotines, croppers and nibbling

machines, with odd cases of precision tools. It would be interesting at this stage to compare the physical properties of cast iron and steel :

Test	*C.I.*	*M.S.*
Tensile	12	26
Shear	10-11	20
Compression	48	26–27

All in tons per square inch.

These figures prove that in compression cast iron is to be preferred to mild steel.

(3) *Mechanised Foundry.* It is safe to say that any work which comes within the capacity of a mechanised foundry will show good results. Three typical examples from many hundreds of conversion cases from jobbing foundries to mechanisation show the following savings in man hours :

Description	*Jobbing*	*Mechanised*
Box for mining gear	210 mins.	70 mins.
Cover for mining gear	195 „	50 „
Bus Bar casting	345 „	55 „

In the latter instance a slight alteration in the design made this large economy.

It will be appreciated that besides considerable saving in cost, there are greater increases in productive capacity ; in the three cases mentioned above increases of 3, 4, even 5 times the original production were obtained. The cost savings will not be so great due to the higher overhead charges, which may be offset by the introduction of cheaper labour.

The size and weight of a job is limited to the capacity of the existing plant and may not exceed 36 in. square and 2 cwts. respectively, but any job within your plant capacity would obviously be more economical made as " castings " rather than as " weldings."

(4) *Corrosion.* Cast iron is better than mild steel from a corrosion point of view, and it is to be preferred if in direct contact with sea or salt water.

(5) *Non-Ferrous Materials.* Castings made in non-ferrous materials are easy, but would cause a certain amount of difficulty if made as weldings.

ADVANTAGES OF " WELDINGS " OVER " CASTINGS "

(a) *Weight.* A correctly designed welding should be much lighter than a casting and in certain cases, for example in the comparison below, it will be noted that considerable savings in weight were obtained by conversion from castings to weldings :

Weight in C.I. (lbs.)	*Weight in M.S. (lbs.)*	*Weight in C.I. (lbs.)*	*Weight in M.S. (lbs.)*
2,700	1,200	15,335	8,000
1,850	850	16,000	9,296
5,576	1,920	2,750	1,200
3,500	1,200	2,625	1,021

These examples covered a range of products required for switchgear, motor and turbine work etc., and the savings in weight were obtained by designing the fabrication exactly as required, so saving the additional stiffeners, ribs, lugs and thicker sections so peculiar to castings because of lower shear and tensile strength.

(b) *Pattern and Tool Changes.* The cost of patterns and cores are, generally speaking, many times dearer than welding fixtures and whilst for smaller quantities weldings can be made by hand, the same procedure cannot be adopted to the same extent in the making of castings.

(c) Weldings can easily be modified in the event of a change in design.

(d) Repairs to weldings are not difficult but cause extreme difficulty in castings.

(e) Weldings are more dependable due to the homogeneous structure of the steel, castings being frequently rejected because of " faults," " blow-holes," etc., these being difficult to locate until after machining.

(f) No necessity to work to a standard pattern, therefore more freedom in designing, particularly in connection with experimental and development work.

(g) More resistance to fatigue.

(h) Less machining allowance required.

(j) It is generally accepted that the manufacture of weldings as a trade is more popular than that of moulding, although during the last few years, managements have tried to improve the lot of the foundryman. Unless serious efforts to encourage trade apprentices into the foundries are made in the near future, then managements may have to resort to " weldings " irrespective of cost comparisons.

(k) No large storage area is required as for patterns and cores.

(l) Less freight charges due to the reduction in weight.

(m) *Comparative costs of weldings and castings.* It will no doubt be appreciated that up to now no relative comparisons have been made regarding costs of either of the processes, and any figures given must obviously be approximate, and must be dependent on an efficient method of manufacture. The following points must therefore be considered :

That cost of weldings can be greatly reduced by the application of manipulators, sub-assembly fixtures, good tooling, and general reduction of handling time.

The secret of successful and cheap designs of welding depend upon reducing to the minimum the actual welding operations ; it is therefore advisable to bend, press or form whenever possible, so as to eliminate the distortion and expense of unnecessary welding and fettling. Typical examples of times show that a saving in favour of bending of 2-1 in minutes per foot for plates up to $\frac{1}{2}$ in. thick, i.e., 12-1 for a plate 6 ft. long can easily be obtained, whilst for plates up to 1 in. thick a saving of 3-1 in minutes per foot can be shown. Bending, besides eliminating distortion, also removes the need for fettling and dressing.

Consideration should also be given to the number of pieces involved in the making of a welding.

This subject can be discussed under two headings :

(1) Whether to save material by reducing the weight and increasing the number of pieces, or—

(2) Increasing the weight and reducing the number of pieces.

From practical experience it is known that the majority of jobs show a saving in man hours and cost, by adding weight at the expense of reducing the number of pieces. By this it is not inferred that the weight should equal that of a casting because any welding weighing the same as a casting is either incorrectly designed or it is not suitable for fabrication. A typical example of this may be seen in a simple cast iron cover with gussets and other projections peculiar to castings. If this was to be made as a welding, all that would be required would be a flat piece of plate flamecut to size.

EQUIPMENT

The question of costs of fabrications must vary with the equipment each firm contains ; a large firm with suitable equipment will produce more cheaply, but the overhead charges will be greater, whilst smaller firms with no bending or folding machines will rely purely on flamecutting and welding, which whilst dearer in actual operation carry a lower overhead expenditure.

MAN-HOURS

The question of man-hours versus material is a question to be seriously considered. For example, let us consider a ring which in the larger sizes would be cheaper to roll and butt weld on a resistance welder than to flamecut out of plate ; but it is also obvious that fewer man-hours are involved in flamecutting than in rolling and welding. I would suggest that flamecutting is to be preferred, although above

18 in. diameter the rolling and welding process is cheaper. It should be borne in mind that there is a limit after which flamecutting is out of the question.

WEIGHT REDUCTION

A comparison in costs between castings and weldings is a very difficult problem, and for your consideration I would suggest that it is safe to assume that the costs of castings and weldings be considered equal for price per ton, but that the weldings are cheaper by the amount of weight reduction which should amount in a correctly designed fabrication to 50% or over. But even with this weight reduction weldings are sometimes dearer than castings, although cases like this are few. We carried out in 1932 a comparison between castings and weldings during the period in which serious consideration was given to the change-over to weldings from castings, and in the nine cases used for comparison, three showed that weldings were slightly cheaper per lb., whilst in six cases castings were the cheaper per lb. ; however, in each of the former cases the weight of the weldings were between $\frac{1}{3}$ and $\frac{1}{2}$ of the weight of the castings, proving without doubt that if the welding is the same weight as the casting, then no economies can be expected.

A typical example can be seen in comparison between fabricated and cast iron motor yokes, and in which due to the difficulty in obtaining castings it was necessary, owing to design difficulties, to produce a yoke identical to the original casting. It was found that no weight savings were effected and although the job was fully tooled, the cost of the weldings was twice the cost of castings. This was accepted as a temporary measure because of shortages in casting capacity and the need to maintain output, but we propose to change back to castings at the earliest convenience.

You will find many exceptions which sway the balance of favour one way or the other and each particular job will require careful consideration.

SUGGESTED PROCEDURE

The time has arrived for us to summarise our findings, and as an individual who handles many thousands of new designs before going into production, I would suggest that you work along these lines:

(a) How many are required ?

(b) Do the characteristics of the job dictate whether castings or weldings should be used ?

(c) How urgent is the job ? This very often decides its manufacture.

(d) If the delivery date is flexible enough for either process to be acceptable, then manufacturing costs must be established.

(e) The materials available at the required time of building.

I propose now to give a few suggestions regarding manufacture and design of weldings, to enable the would-be user to make a favourable comparison with castings.

MANUFACTURING COSTS

Manufacturing costs can be calculated for established lines, e.g. condensers, switchgear, motors, meters, etc., and compared with their equivalent cost as castings. These can then be amassed and tabulated for future reference. If the costs are nearly equal, then tool and pattern changes, availability of material, or alternatively, the number of man hours will decide the final issue. I have known cases of equality which have turned in favour of weldings by increasing the tooling facilities and an extensive use of manipulators. The answers to the five questions mentioned above will generally be all that is necessary to provide the correct answer but consideration should also be given to the following suggestions.

If large quantities are required, it is advisable to make to scale either a cardboard, wooden or steel model of the product, and consider if it can be made in sub-assemblies. The advantage of this is a reduction of the work in progress caused by three or four assemblies going through concurrently, whilst another advantage is that straightening and removal of distortion can be more easily carried out in the detail assembly stage than in the final position.

The use of manipulators cannot be over emphasised. To the tool and process engineers I would recommend serious consideration of the following suggestions :

Wooden or steel templates for all quantities over 20 per annum.

Checking and development templates for quantities over 100 per annum.

Cheap welding fixtures for quantities over 30-50 per annum.

Good class welding fixtures for quantities exceeding 200-300 per annum.

It is expected that certain anomalies may arise which may vary the above figures, but generally speaking the principle suggested is fundamentally sound.

Welding fixtures may come under two headings :

(1) The type which holds all the necessary parts in position for welding.

(2) The type which owing to the size of the job fits inside to hold or check certain parts of the component, although it may be

necessary for quite good fixtures to be made even for small quantities off ; a typical example is the welding of links on to a machined shaft.

To the designer, engineer, or draughtsman I would say—" Do not copy the undermentioned characteristics of castings, when designing weldings."

DESIGN PROBLEMS

(1) The taper which helps a casting in the withdrawal of the pattern.
(2) The curves which help the molten iron to flow.
(3) The change of sections, usually gradual, to assist in cooling and to avoid holes and cracks.
(4) The thick sections used in castings because of low ductility.
(5) The excess number of ribs and gussets to aid stiffness.
(6) Excessive machining allowances.

To summarise my remarks into one sentence, I would say—" Avoid designing cast iron ' weldings '."

A word on weldings as an alternative to steel castings or riveting. The weight of steel castings and mild steel weldings is almost identical, but the price per lb. is cheaper in weldings. The advantages of weldings over riveted constructions can be summarised under the following headings :

ADVANTAGES

(1) Weight of material is less ; in the slide of the 3.7 Gun Carriages the riveted type weighed 25 cwts , the welded type 20 cwts.
(2) No holes required, therefore stronger and cheaper.
(3) One welder supplants a four-man rivet gang.
(4) Process is noiseless.
(5) Joints are sealed against moisture.
(6) The majority of steel can be shipped to construction sites.
(7) Changes can easily be made.

ELIMINATION OF DISTORTION

The question of distortion in welding is always with us, but if a job is designed correctly and the welding procedure laid out beforehand, this difficulty can be reduced to a minimum.

Distortion is caused by the expansion or contraction of the materials during the welding process.

In welding, the fused metal, as it is at a high temperature, is expanded in size at the time when it begins to become solid, and as it cools it tends to shrink ; ordinary steel if not restricted contracts in every direction about 1% whilst cooling. The following suggestions will help in reducing distortion to a minimum :

(a) The depositing of welds of a given size should be done in the smallest number of runs by the largest diameter electrode.

(b) A welding procedure should be adopted to equalise position of welds.

(c) Make the job in sub-assemblies.

(d) Good preparation of material and fit.

(e) Welding fixtures for holding.

(f) Clamping back to back and stress-relieving or fitting of temporary stiffeners.

(g) The size of weld should not be greater than that required to develop the strength required by the component.

(h) Two or more welders working concurrently.

(j) Reducing to a minimum the amount of weld metal deposited by increasing the mechanical formation of materials, i.e., pressing, bending, forming, etc.

In closing I would like to summarise the talk as follows :—

SUMMARY

(1) That the general comparison of costs between weldings and castings can be considered almost equal per lb.

(2) That a suitable correctly designed welding should be much lighter than a casting, hence its cost should be correspondingly less.

(3) That it is impossible to generalise on all types of work, because either castings or weldings can show definite economies on certain types of work.

(4) That the final choice must depend essentially on costs, delivery dates and the plant available.

I have tried to present to you a paper designed rather from an interest than a technical point of view ; explaining, I hope, the two main methods of manufacture, and giving a picture of fabrication as applied to light and medium sized components.

DISCUSSION

MR. NEWBOLD wanted to know if there was any particular angle at which faces should be bevelled to the advantage of the welding, and also the width of the face in reference to the thickness of the material.

Mr. WATTS replied that there was a standard for fillet welds, in that one could have a light, medium and heavy size of weld for every type of job. If it was a heavy load i.e., if it was highly stressed a heavy weld would be required. For butt welds, there was a definite standard of weld chamfers of given dimensions and whilst in the old days it was left to the individual to apply any chamfer he thought fit, in these days of modern fabrication practice, with its

many different conditions, the need for stricter control was apparent. For very heavy welding in thick material one did not apply a straight chamfer at all, but rather a " J " or " U " machined preparation ; this was partly to eliminate the very wide gap which would exist even with a small angle, a gap incidentally which might be useless from a strength point of view ; all welding preparations were related to the thickness of the material, the conditions required and the geometry of the job itself, and whilst there were different angles for any required condition, it was generally accepted that for butt welding a combined angle of 60°, that is 30° on each plate was ideal. However, he would not be definite without knowing the particular requirements.

Mr. Scott asked for comments on the difficulties of welding materials of different thicknesses, say $\frac{1}{32}$ in. thick welded to $\frac{3}{16}$ in. or $\frac{1}{4}$ in. thick.

Mr. Watts said there was some difficulty attached to the welding of different thicknesses of materials, not so much in the thicker materials i.e., $\frac{1}{2}$ in.—$1\frac{1}{2}$ in. or over, which were comparatively easy to a skilled welder, but rather the thinner sections as mentioned in the question. The danger lay in controlling the current so that the thinner of the materials was not melted, whilst at the same time, it was sufficient to make a suitable penetration into the thicker plate ; in other words, electric arc welding depended on the electrode melting before the thinner materials and a higher current was required to weld satisfactorily the $\frac{3}{16}$ in. or $\frac{1}{4}$ in. materials than the $\frac{1}{32}$ in. thick plate.

Mr. Field said that in this area there were many people who objected to welded structures in connection with machine tools. He wondered if Mr. Watts could tell them if it was just because it always happened to have been cast iron that it was better, or whether the welded structure was just as good, taking into account that after having welded a rather large piece of fabrication it could not always be annealed because there might not be a furnace large enough. On the other hand, iron could be left in the open to stabilise.

With regard to smaller equipment, such as jigs and fixtures—milling fixtures, for instance—he would like to know Mr. Watts' experience with regard to resistance to vibration, whether the fixtures were still " live " and after a period would distort ?

In reply to the first question, Mr. Watts said that whilst it was an established fact that in some cases fabricated machine tools had been successfully made, he was of the opinion that the fitting of cast iron or brass bearing surfaces so essential for machine tools, with its consequent increase in man-hours, outweighed any advantage to be gained by fabrication as compared to castings. Weldings were certainly more " alive " than castings even after

stress relieving, and whilst he was convinced that in the near future great strides would be made in popularising the uses of weldings in the Machine Tool Industry, he thought that it would be restricted to nibbling machines, guillotines, plate folders, and the like and also for special lines.

In regard to the second point, Mr. Watts personally used mild steel fabrications in preference to cast iron on punch and die shoes for press tools, and on milling and drilling fixtures etc. ; he thought this advisable where there were a variety of designs, although there was a case for castings when jobs were standardised and several hundreds of one design of equipment could be ordered. With reference to measuring and marking out equipment, cast iron was preferred in the design of scribing and vernier height gauge bases and other similar conditions in which it was necessary for the tools to slide ; the graphite in the cast iron acted as a lubricator.

MR. BRITTAIN asked what arrangements Mr. Watts made in his own factory for the inspection of his structures. He was particularly interested in the manufacture of pressure vessels where he believed, in this country, riveted construction with dish ends riveted to the shell was insisted upon, but in America he thought they had been welded. Were there any instruments for determining the quality of the weld, or did Mr. Watts in the main depend upon physical tests to determine the strength and so on? Mr. Brittain was also interested in the welding of stainless steel which was a rather difficult problem. He had a little experience on the stainless steel used in dealing with sulphuric acid fumes and splash and so on, and this had been unsuccessful on the whole. After welding there was a rusty appearance where the weld had taken place, and there was inconsistency in the various stainless steels.

MR. WATTS said that his firm had not yet made a riveted pressure vessel in all their experience of fabrication work, and he would say at that juncture that all pressure vessels were covered by outside inspection ; generally, Insurance Companies had their own inspectors who periodically visited and watched the job in all its phases. They insisted that a section of the material be kept as a test piece, this being obtained by ordering the component larger than was required, and using this for the purpose of the test ; this was then welded by approved welders (certain welders were trained for particular jobs). The test piece was then subjected to the required and approved tests and the pressure vessel when completed had a final pressure test of water or air ; some contracts still insisted on the lifting tackle being welded and riveted on, rather than relying on the weld only. This was in the majority of cases entirely unnecessary, and in many cases the people concerned had been convinced that welding, plus interlocking, was quite sufficient.

Regarding the second question, Mr. Watts stated that there was

not a lot of difficulty in welding stainless steel, providing that the correct electrode was used ; there could be a certain amount of weld decay as suggested, but he had seen cases where this had been cured by changing the electrode. Stainless steel could be supplied in so many forms—some had good drawing qualities, others would weld exceptionally well ; although there were many which would not conform to both conditions, on the other hand a few would both press and weld satisfactorily. He thought the answer lay in experimenting with the different types until the correct one was found, after which there should be no difficulty in producing the job without weld decay. The makers of stainless steel would help in the decision.

MR. HARRISON asked Mr. Watts for his views on stress relieving. He had found in placing business with firms specialising in welding that there was still a marked divergence of practice ; some insisted on stress relieving, others said that if a firm was calling for it, it was because they were putting stresses in unnecessarily. He would also like to say something about the use of fabrications in machine tools. It was surprising how many today had got fabrications in them, more particularly those of a special purpose character, where the incidence of pattern costs made the possibility of economies very great. Generally it was not realised that so many fabrications were used, because they were such a good job that they were not noticed as fabrications. He thought most of the people who were in quantity production did not use fabrication but still adhered to the pattern and casting method, with some notable exceptions.

MR. WATTS said that for a considerable time it had been purely guess work as to whether a job should be stress relieved or not. It was generally assumed that condensers, turbine work, motor yokes, or any job which was of a fairly strong design, and which was not seriously over-stressed should not be stress relieved, whilst conversely jobs which were flimsy or fragile and were likely to become " alive " in use should be stress relieved. He himself thought that more work was stress relieved than should be, and when the size of an annealing furnace and the amount of gas or oil consumed hourly, plus the numbers of hours in heating up, holding and cooling down, were taken into account, the expense incurred was considerable and great care should be exercised in analysing the appropriate job to stress relieve. With regard to machine tools, he made reservations regarding certain types which were suitable for fabrication purposes. The point he wished to make was that assuming that it was not one off (which might not justify the cost of expensive pattern and cores), generally speaking castings were cheaper than weldings, particularly if of a standard design. Once the initial cost of the patterns and cores were paid

for, the price was obviously lower when the amount of work involved in fitting the slides and bearing surfaces to the fabrication was considered. He did not say that the machine tool industry would not take up fabrication on a large scale, but his personal opinion was that revolutionary ideas and methods would have to be used to compete in price with castings.

MR. BROWN inquired if Mr. Watts had encountered the problem of using castings in simplified form and joining them together, and if so with what success?

MR. WATTS replied that it was difficult to visualise concrete uses of castings used in conjunction with weldings, but one simple case was the use of fabricated expansion joints made up of a series of pressings welded together, which fitted between various cast iron pipes on steam turbines. Another case was a condenser shell entirely fabricated and fitted to a cast iron waterbox. There were of course many other cases of castings and weldings being intermingled to form a certain manufactured product.

MR. BURGESS wished to pursue Mr. Harrison's point regarding machine tools. He was having machines made by an American company, entirely fabricated, and he believed that quite recently one of the largest clearing presses of its type was made in this country and installed in a press shop at Acton. That was an application which he thought underwent every possible stress and strain and it had been largely used in the States. He contended that this was an application that had been tried, proved, and used by large manufacturers in the States over a considerable period—since long before the war. There was proof, more or less, that it had been properly developed, supporting the remarks made by Mr. Watts that it had been properly studied from the design point of view and put into factory use.

MR. WATTS said he had visited the majority of the exhibitions at Olympia and had taken particular interest in the clearing press referred to and also the method adopted for changing it to a guillotine. He had admired the fabricated construction, but had emphasised that brake presses and nibbling machines were an ideal job from the fabrication point of view. The machines he referred to were precision machines e.g. milling and grinding machines, lathes, jig-boring and Keller machines etc., which required a tremendous amount of solidarity and contained a large amount of wearing faces. He entirely agreed with Mr. Burgess in regard to ones off in connection with presses, folders, guillotines, etc., but if the design became a standard manufacturing proposition, he thought castings would be cheaper—it was a question of quantity, quality, and cost. His firm had installed an old cast iron folding machine which was about 28/29 years old and about 18 months ago one of the sides completely broke into two pieces. They had the

choice of waiting 18 months or 2 years for a replacement, or to make a welded fabrication. The decision to fabricate had justified itself and the machine had operated without difficulty for the last 12 months. He would not say that a precision tool could not be fabricated, but he personally considered that at present and in his experience, cast iron was more economical than mild steel.

MR. FARREN asked for information on welding steel plates to cast iron.

MR. WATTS, in reply, said that cast iron contained approximately 3.2% carbon. If heat was applied with quick cooling, the iron became chilled and cracked. A deposit of weld metal could be placed down on a joint formed on one side by cast iron and on the other by mild steel, and the result would be good penetration in the mild steel, but a crack would be seen at the junction of the cast iron and the weld. The reason was that the cast iron in cooling from the high temperature became air hardened, and to overcome this difficulty in cast iron welding the component to be welded was usually heated in a muffle and allowed to cool slowly. All steels up to .3% carbon could be welded without preheating ; steels from .3%—.6% approximately should be preheated, whilst all steels above .6% could not be welded at all by fusion welding.

Cast iron welding was not considered a practical proposition for commercial work, but rather as a means of carrying out repairs etc. By heating in a muffle as already stated very good welds could be made, but the welding of cast iron to mild steel should be discouraged for a number of reasons. It was common practice in the repair of cast iron machine tools to insert screwed plugs of mild steel, and by welding the joint and studs, additional mechanical strength was given to the repairs.

MR. FIELD, referring to the stud question, asked for information on the resistance welding of studs, and the strength relative to the normal method of drilling and tapping.

MR. WATTS replied that stud welding was carried out by two methods, the first by resistance welding, the other by a similar process to metallic arc welding ; dealing first with the latter process the principle was that, as in arc welding when the electrode in a suitable holder made an arc with the work, a molten pool was formed, so in stud welding the stud in a suitable holder formed the arc with the work and at a predetermined time the stud was mechanically pushed into the molten pool. The equipment was made by a number of manufacturers and the advantages could be seen particularly on transformer tanks where studs had to project outside the tank, which was required to be oil tight.

The old method required the drilling of a suitable hole, and the manufacture of shouldered bolts, these being arc-welded inside the tank. The studs for stud welding were chamfered to a point

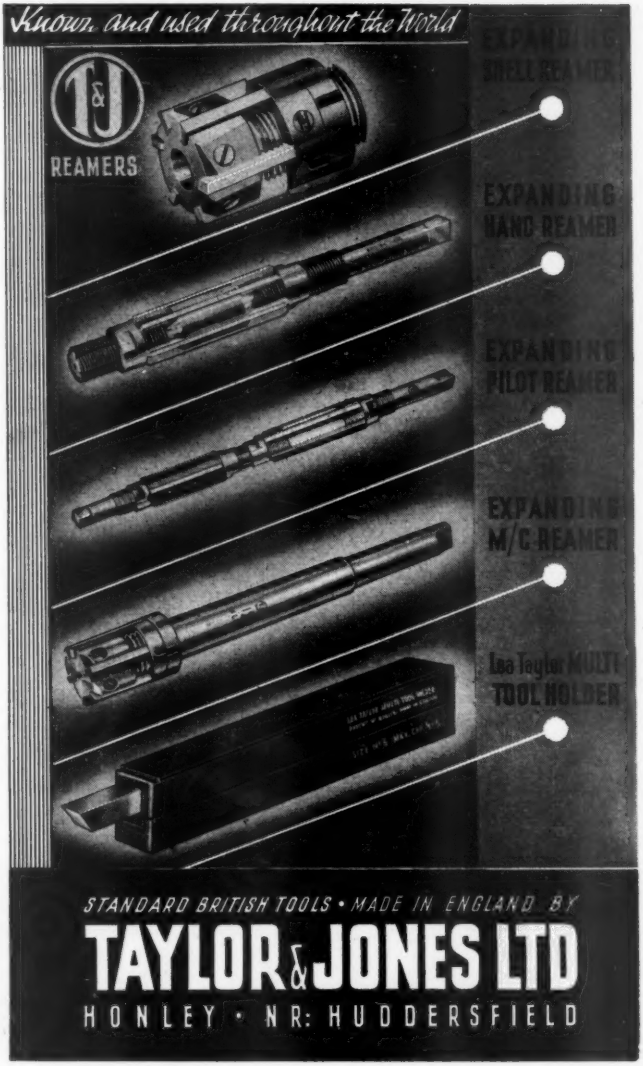
which facilitated its setting on to a centre pop marked on the plate, this latter operation being marked out either by hand or by using a template ; occasionally the legs of the tripod were used as a means of setting the studs to each other. This method of fastening the studs was comparatively new when compared to the resistance method, which in itself was a process similar to spot or projection welding. In spot welding two tapered electrode holders, through which a current passed, were used ; on meeting a resistance caused through two plates being between them, heat was generated and the weld was made by mechanically pressing the electrode together. Two pieces of plate were used, one of which was indented mechanically ; then by using two flat electrodes, the current was passed through the projections to form the required weld.

If the end of the stud was made in the form of a curvature or shape so as to reduce the area of the contact, excellent welds could be made. It was advisable in some cases actually to drill holes in the studs or bosses before welding, particularly if the studs or bosses were at the bottom of a deep tank, which might make it difficult to reach for drilling, and with special tools or templates an accuracy of $\frac{1}{64}$ in. between centres should be obtained. This accuracy was dependent on the holes in the copper electrode or the template being correct. The strength of the weld was equivalent to the weakest strength of the material.

MR. FIELD said he was thinking in terms of the accuracy of automobile rear axle shafts. His firm normally drilled and tapped, and then put the stud in. He wondered if Mr. Watts had come across putting the studs in direct on to the metal.

MR. WATTS replied that in this case the accuracy required could not be achieved unless the studs were contained in a hole or series of holes with definite centres of location. If the studs were dealt with separately, using templates, it would depend on the accuracy of the setting.

MR. WATTS in reply to a question from Mr. Walls, said that in projection welding the deepest radius at the bottom of the stud was about .04 in. ; it was not a chamfer but rather a radius whose dimension measured from the crown to its two edges, this varying according to the thickness of the dimension material. Certain other shapes were permissible to reduce the contact area and in the event of the diameter of the stud being too large for the resistance welding machine, it was perhaps advisable to put the projections on to the plate itself.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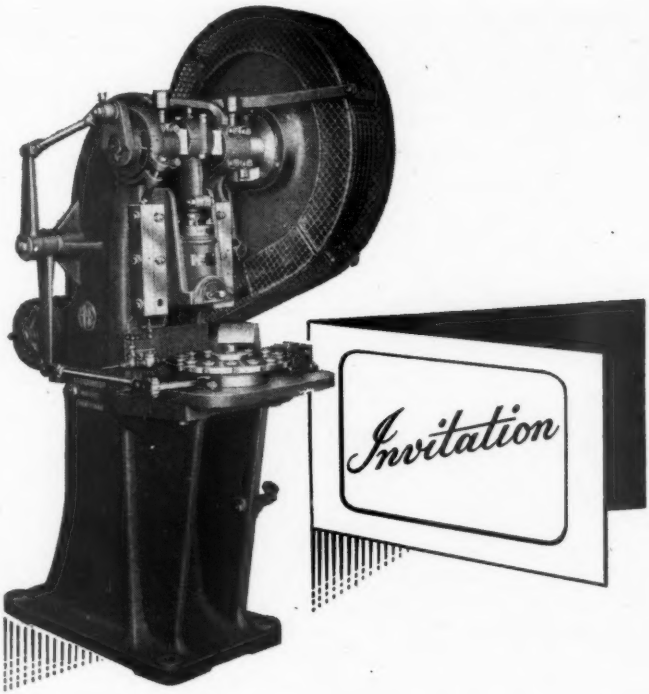

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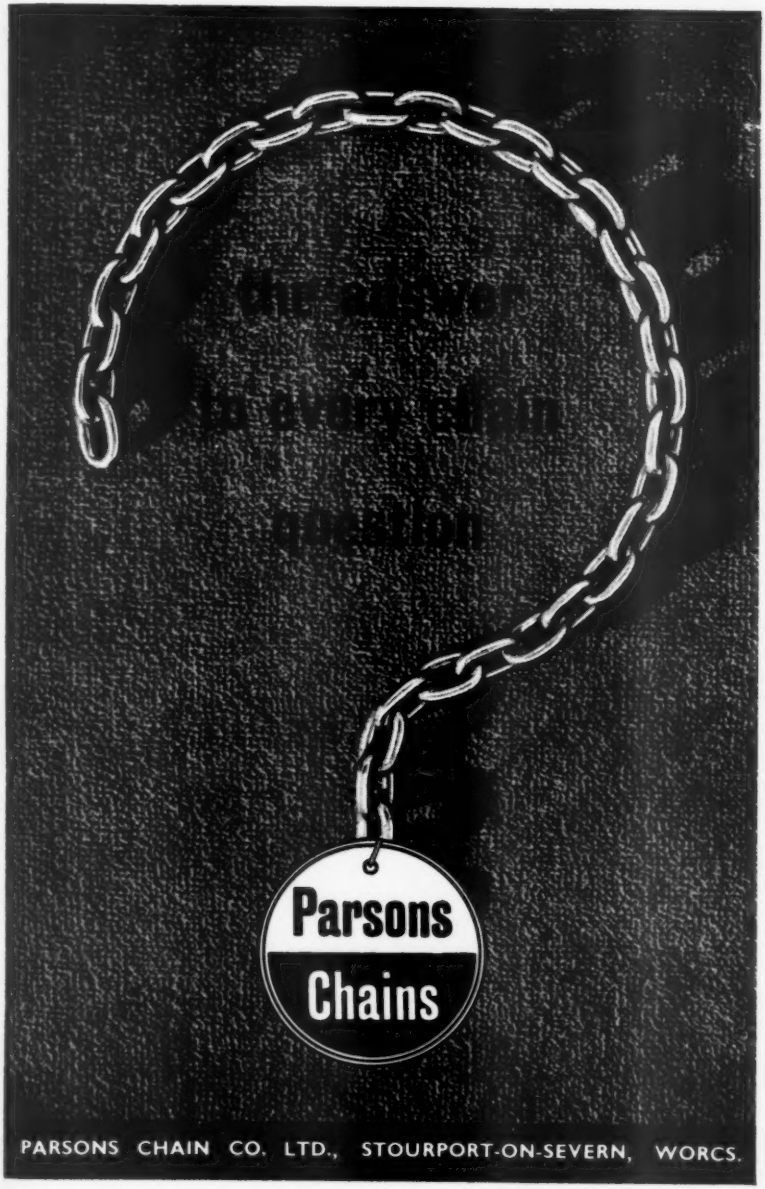
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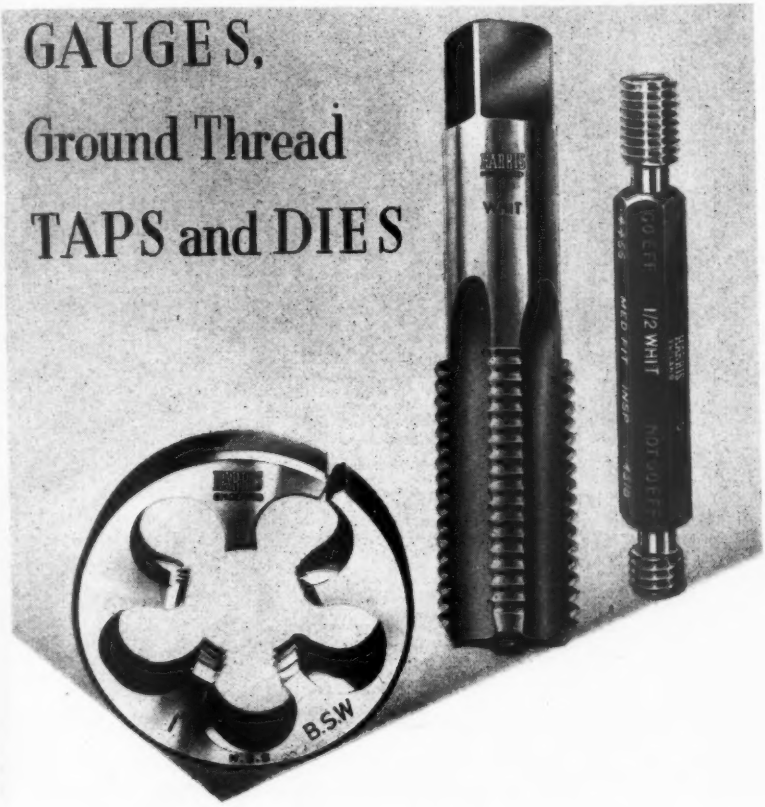

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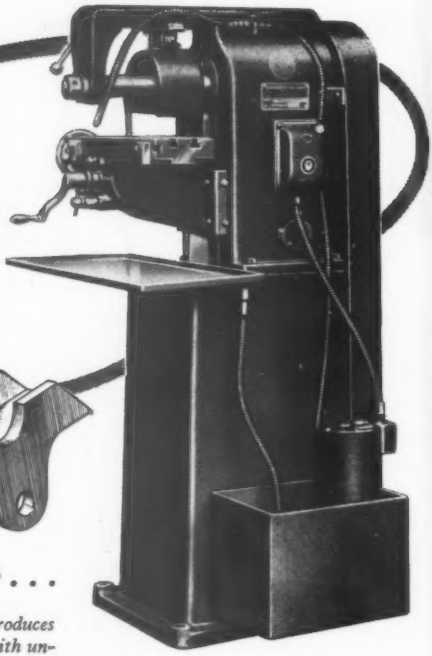

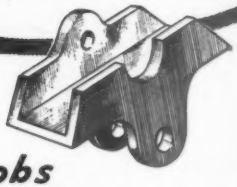

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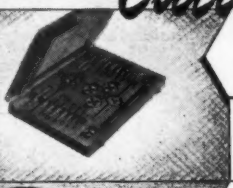

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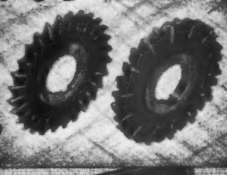

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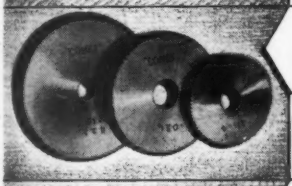

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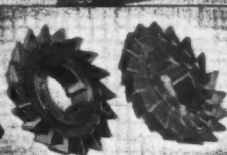

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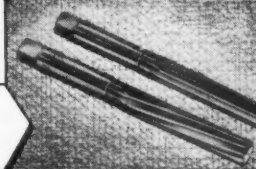

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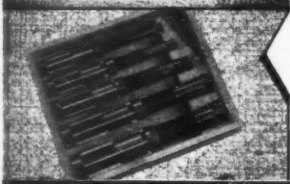

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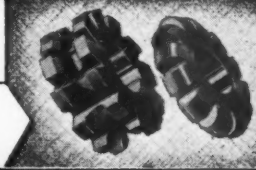

High speed steel Cutters, convex and concave. Standard holes and keyways

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STEPS..

TO SAFETY

FOR USERS OF ZINC ALLOY PRESSURE DIE-CASTINGS

Due to the change over from wartime conditions there is a considerable amount of secondary and re-melted Zinc Alloy in circulation . . .
Inter-crystalline corrosion caused through an impurity content of even a few thousandths of 1%, endangers the life of your castings. Protect YOUR interests by taking TWO STEPS . . . .

STEP No 1 Specify Zinc Alloy Die-castings which conform to B.S.S. 1004.

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GRAISELEY HILL . WOLVERHAMPTON

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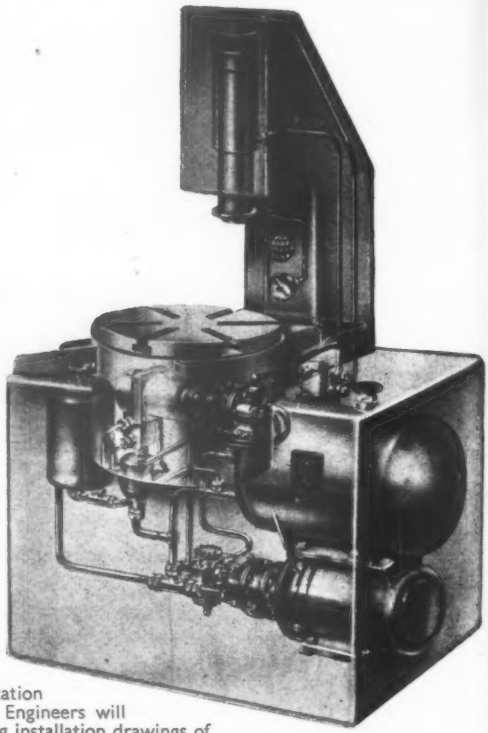
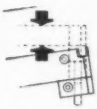


Hydraulic circuits can be designed and built up from standard Keelavite pumps motors, valves etc., to solve any problem of power distribution particularly when varying speed, varying load, frequent reversal or movements in sequence are important factors. Given detailed information relating to the proposed application of hydraulic power, Keelavite Engineers will put forward proposals, including installation drawings of the units concerned, hydraulic circuit, and any necessary electric control unit.

KEELAVITE ROTARY PUMPS & MOTORS LTD. ALLESLEY, COVENTRY

Wimet
KNOW HOW

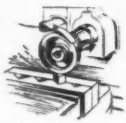
Note these advantages!



LONGER CARBIDE LIFE Adjustment provided to raise the 'Wimet' insert in the holder permits full use of carbide.

MANIFOLD CUTTING POINTS. The numerous cutting edges can be quickly brought into use by simply repositioning the tip in the holder.

STANDARD CARBIDE INSERTS. Standard, circular and triangular inserts are available from stock.



SIMPLIFIED SERVICING Simple surface grinding on the top face is all that is necessary.

Wimet Clamptip tools consist of toughened steel shanks, fitted with interchangeable triangular or circular 'Wimet' Tungsten Carbide inserts. Securely held, the inserts provide completely stress-free cutting tips to which any required top rake can be applied, and may be quickly repositioned in the holder to bring into use any one of their many cutting edges.

'Wimet' Clamptip Tools reduce carbide costs, save production time, simplify and cut the cost of servicing. They are available from stock in the following sizes: ½in. x ⅜in. x 5in.; ⅝in. x 1in. x 6in.; 1in. x 1¼in. x 8in.

The Wickman Technical Publications Department will gladly send you full details of these versatile tools. Write for literature today.

"THE WIMET AGE," *a 16 mm. instructional sound film on the Application of Tungsten Carbide tools is now available for exhibition in Engineering Works, Technical Colleges, etc. Please write for details.*

Wickman for Wimet TUNGSTEN CARBIDE

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LONDON · BRISTOL · BIRMINGHAM · MANCHESTER
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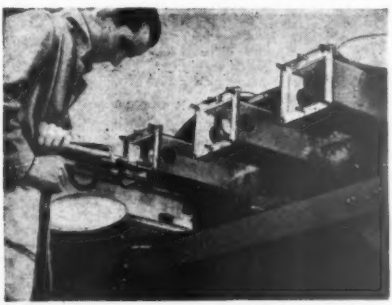
Weld your studs LIKE A SHOT

14 times faster than drilling and tapping

Wherever you want to fix studs to steel, take a Nelson Stud Welder to the job. It is so easily portable that it will go almost anywhere—as easy to handle as an electric drill and far safer.

You can be certain that every weld is neat, uniform and strong because the welding operation is entirely automatic. No welding skill is called for. You can use it for precision production work where studs were previously inserted by drilling and tapping, and do the job 14 times faster. You can use it where studs were never used before, because the Nelson gun makes stud fixing quicker and cheaper than bolting, riveting, pinning or any other form of fixing.

Find out how this time-saving, cost-cutting technique can help *you*. Send to-day for the new Nelson Brochure.



The Nelson gun in use on production of high voltage switchgear—one of a wide variety of cost-cutting, time-saving jobs for this versatile tool.

NELSON STUD WELDING SERVICE

CROMPTON PARKINSON LIMITED
PLANT DIVISION
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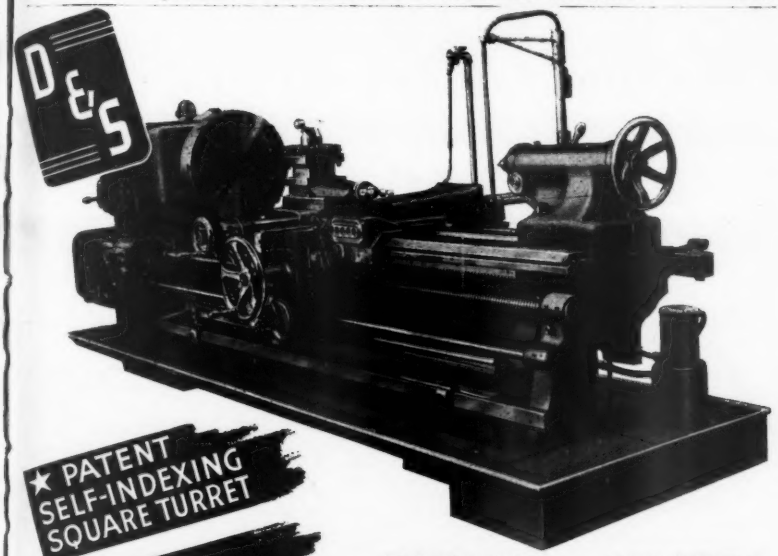

★ PATENT SELF-INDEXING SQUARE TURRET

★ PATENT QUICK POWER SADDLE TRAVERSE

★ PATENT FORCE FEED LUBRICATION

★ QUICK ACTING MULTI-TOOTH CLUTCHES

★ COVERED BEDWAYS

DARLING & SELLERS
10½" Centre LATHE

This lathe worthily takes high place in the machine tool aristocracy as a perfect example of the highest standards of British craftsmanship. Designed and built for faster production for longer periods, D. & S. 10½" centre Lathe can fully justify its installation in any modern machine shop.

* *The illustration shows a D. & S. 10½" Centre Gap-bed Lathe without Rapid Power Traverse.*

Details and descriptive matter on application

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Drilling, tapping & re-tapping

PLASTIC KNOBS

with ONE handling!

The great possibilities for time-saving through the use of GOVRO-NELSON Automatic Drilling Units is illustrated in the above 3-unit automatic set-up for drilling, tapping and de-burring set screw holes in plastic knobs.

One unit drills the set screw hole through the plastic and aluminium insert with a combination drill and counter-bore. A second unit then taps the aluminium insert for the set screw, after which the third unit (below indexing table) re-taps the center hole to de-burr.

Let us show you how you can simplify your complicated drilling and tapping operations with GOVRO-NELSON units.

FULL PARTICULARS ON REQUEST

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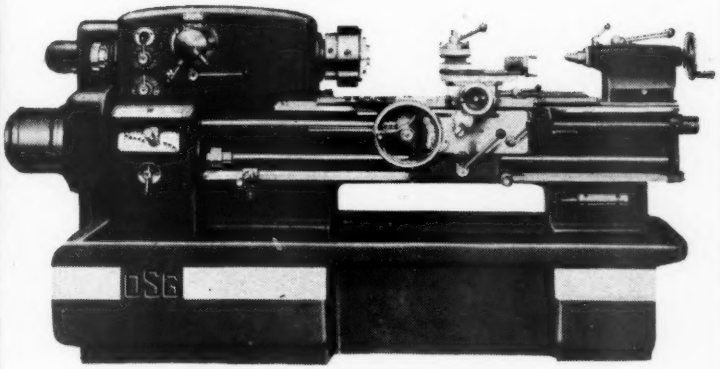
For High Class Production or Toolroom Work

TYPE 13



13" SWING PRECISION LATHE.

from our New Range 13" to 30" Swing

Flanged Vee Rope Motor Drive
Self-Adjusting Clutch
Middle Bearing to Spindle
Final Drive to Spindle by Vee Ropes
Patent "Fastlock" Spindle Nose
Wide Range of 12 Spindle Speeds
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THE LATHE PEOPLE
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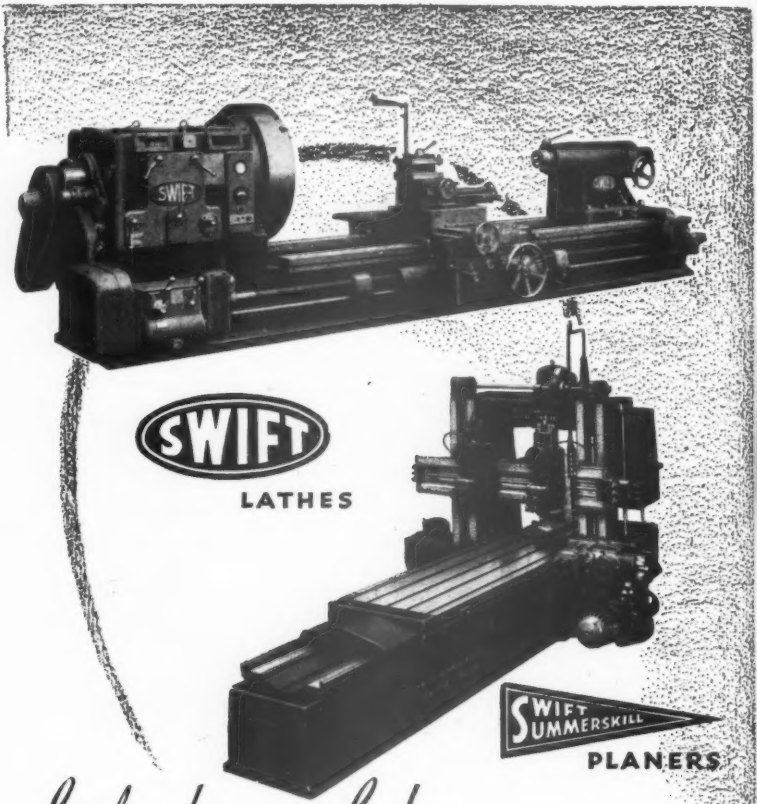

Leadership in Lathes
Perfection in Planers

SWIFT LATHES are built as both Centre Lathes and Surfacing and Boring Lathes, and range from 17in. swing to 72in. swing, with any length desired between centres.

SWIFT-SUMMERSKILL PLANING MACHINES are built from 2ft. 0in. square up to 5ft. 0in. square, of any length of table up to 40ft. 0in., of both Double Column and Openside types, with either all Electric or reversing Two Belt Drive. Special All Electric Feed Motion.

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THE
PEGARD BORER

Traversing Spindle $3\frac{1}{8}$" diameter with Automatic Facing Head to face up to $31\frac{1}{2}$" diameter. FULL SPECIFICATION ON APPLICATION.

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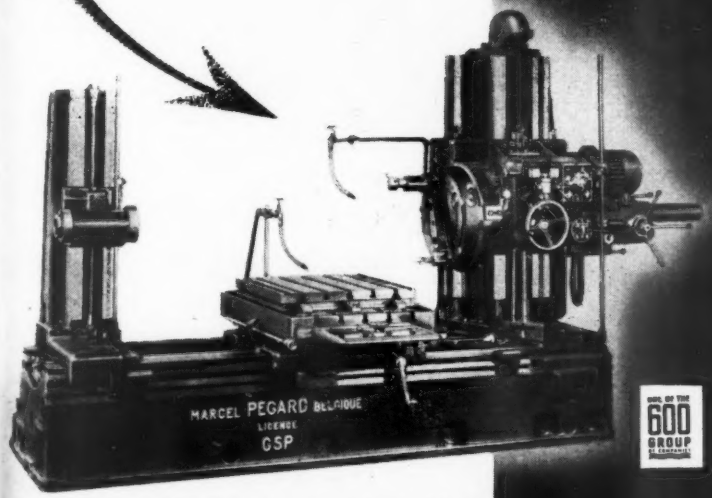

A number of these Borers are operating in this Country and demonstrations can be arranged.

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MAZAK for pressure die castings

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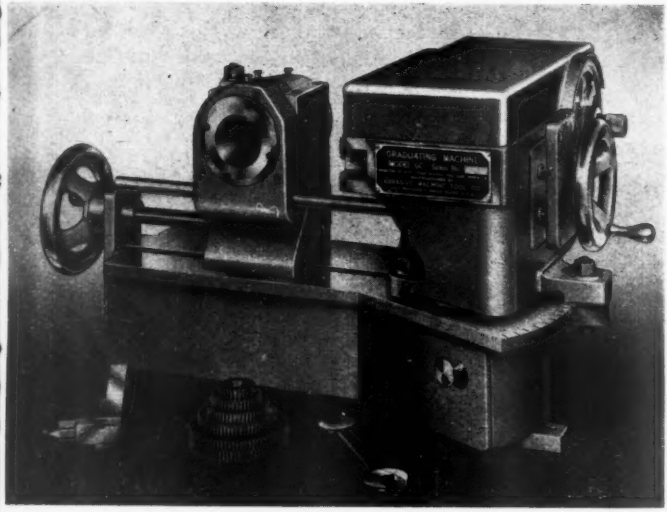

CIRCULAR
GRADUATING
MACHINE

A new machine for the rapid and accurate graduating of handwheels, dials, knobs and similar components of machinery and other equipment.

Capable of a wide range in the number of English, Metric and "Degree" graduations; the spacing of graduations is controlled through change gears and worms, thus "Dividing Head" accuracy is assured.

Graduations parallel with work axis, or angular graduations up to 45° can be cut to pre-determined length and depth.

From 125 to 150 graduations per minute can be produced on work from 1½in. up to 20in. diameter on this power driven, self-contained machine which is only 38 in. × 21 in. × 15 in. high.

Further details on request.

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FACTORS OF HIGH CLASS MACHINE AND SMALL TOOLS

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To PRODUCTION ENGINEERS

and especially those who are expected to boost output on semi-obsolete machines.

FLOOR-TO-FLOOR EFFICIENCY.

A semi-obsolete machine can produce something akin to the output of a modern machine by the use of up-to-date air clamping equipment. Example :—

(A) Using hand-clamping method.

Handling time 30 secs.
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= 1 unit per minute.

(B) Using Enots Air Clamping Equipment.

Handling time 10 secs.
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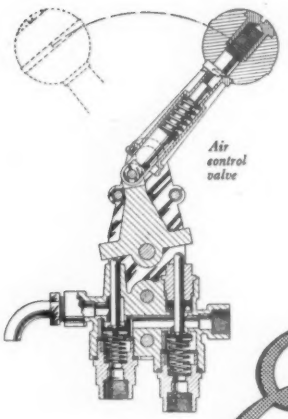
= 1 unit per 40 secs.

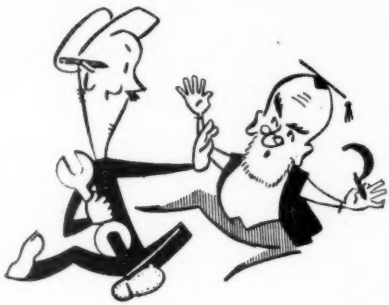


Now, don't say "my work's different!" You can't really say till you've had a talk with us. And please don't put the matter aside. If you don't need air clamp equipment we shall soon tell you. If you do need it — you need it *now*. Let's get together on this.

Enots

AIRCLAMP PNEUMATIC EQUIPMENT

BENTON AND STONE LIMITED · BIRMINGHAM



Will Might, the Mill-wright
——and the PROF.
set-too No. THREE

"SO you're Will Might the Mill-wright! I can't say I like your face any better than when I first saw it, but let that pass. Take your seat and I'll endeavour to flash some rays of enlightenment into the dim recesses of the cavity normally a cerebrum."

"Yes, Prof.—and tell us something new about belts. How long is an endless belt, for instance?"

"As a matter of fact, that's the subject I had intended. Now, first of all, what is a belt? This you appreciate, depends upon whether we consider the subject as the lateral periphery of the circumference as a flattened ovoid, or....."

"Don't be daft, Prof. an endless belt is a weekend in Blackpool, Hah! Hah!"

"Silence! Will Might—what even theoretical relationship exists between the penultimate portion of a week spent in the supreme resort of British recreational conviviality, and an endless belt, may I ask?"

"Prof. that's where theory fails, Cock. In the case of a Hendrys' there's no end and no beginning, as you told us last week, splice or no splice; but a belt at Blackpool soon ends, particularly if you're spliced, Hah! Hah!"

Hendrys'
BELTING

JAMES HENDRY LIMITED
LAMINATED LEATHER WORKS
252 MAIN ST., GLASGOW, S.E.

LONDON: KINGSWAY HOUSE, KINGSWAY, W.C.2
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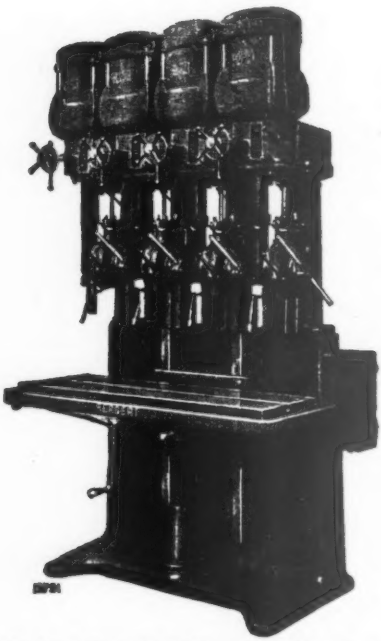
MOTOR-DRIVEN HIGH-SPEED DRILLS

A complete range, operated on A.C. or D.C. voltage, for drilling and tapping from the smallest holes up to 1¼ in. diameter.

Made with 1, 2, 3, 4 or 6 spindles, either column or bench type. Speeds up to 18,000 r.p.m.



Herbert Type V Drill. Capacity: up to 1in. in steel; 1½in. in cast iron.

Features include: finger-tip control, instantaneous starting, stopping and reversing of spindles, instantaneous speed changes; all spindles efficiently guarded by telescopic guards.

Machines are supplied suitable for either general purpose or manufacturing work.

Unit construction enables different types of top columns to be mounted on the same base, providing an exceptionally wide speed range on the same machine.

Full particulars on request.

EARLY DELIVERY

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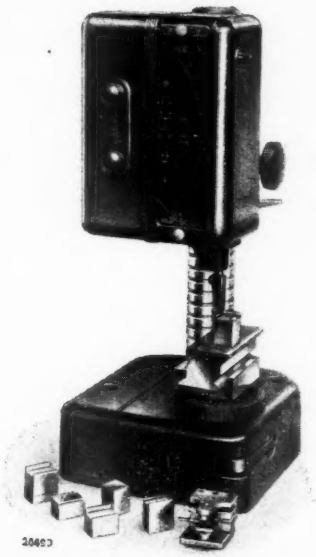
HERBERT



THE SIGMA COMPARATOR AND QUALITY CONTROL

SIGMA COMPARATORS can be provided with simple fixtures which enable the machine operator to check all essential dimensions of his product on ONE instrument without resetting.

He is thus able to control quality during production, pending a final 100% check on the SIGMA MULTI-INSPECTION MACHINE.

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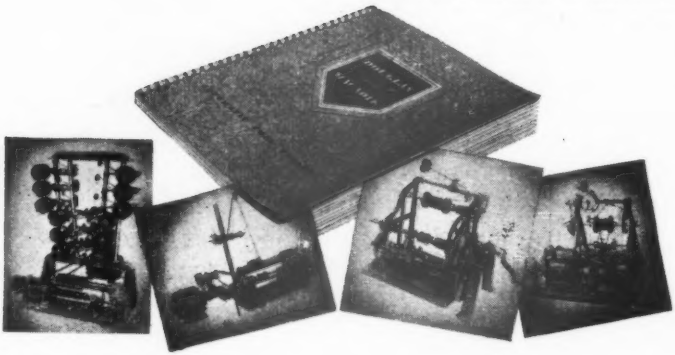
Automatic

COIL WINDERS

The large illustration depicts the new improved "Douglas" Fully Automatic Multi-Winder, specially developed for the high-speed production of large quantities of coils with or without paper interleaving. It will produce round, square or rectangular coils up to 6" each in length and up to 4½" diameter. As many as 12 smaller coils can be wound simultaneously within the total available winding length of 12 inches, at headstock speeds of between 600 and 2,000 r.p.m.

Twenty-two different Coil Winders and Taping Machines are illustrated in our new Catalogue, a copy of which will be sent to interested executives on application.



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C.3

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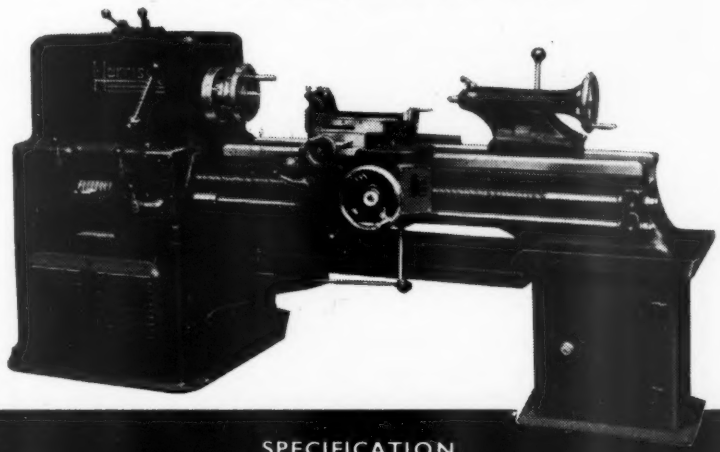
A precision lathe of sturdy construction, specially designed for high production and easy maintenance. Pushbutton stations on apron and headstock minimise operational fatigue and provide immediate control. Ideal for toolroom or general purpose production.

Available through leading Machine Tool Merchants.



SPECIFICATION

Swings over bed 14" • Swings in gap 24" • Distance between centres 3 feet to 6 feet • Spindle bore 2" Spindle speeds (12) 20-400 or 30-600 • Norton Gearbox feeds 32 • Motor 3 H.P. or 5 H.P.

T. S. HARRISON & SONS LTD., UNION WORKS, HECKMONDWIKE, YORKS.

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A comprehensive range of Bull fractional horsepower motors is now available, and early deliveries can be arranged.

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BULL MOTORS

(E. R. & F. TURNER LTD.), IPSWICH, LONDON, MANCHESTER, BIRMINGHAM, NEWCASTLE, GLASGOW

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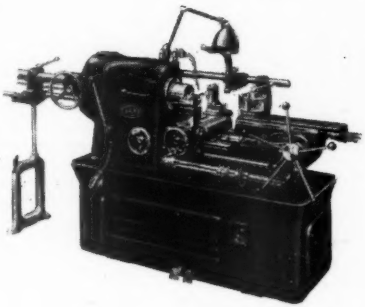
'JOYSTICK' Boosts Output

The hour . . . The need . . . The machine

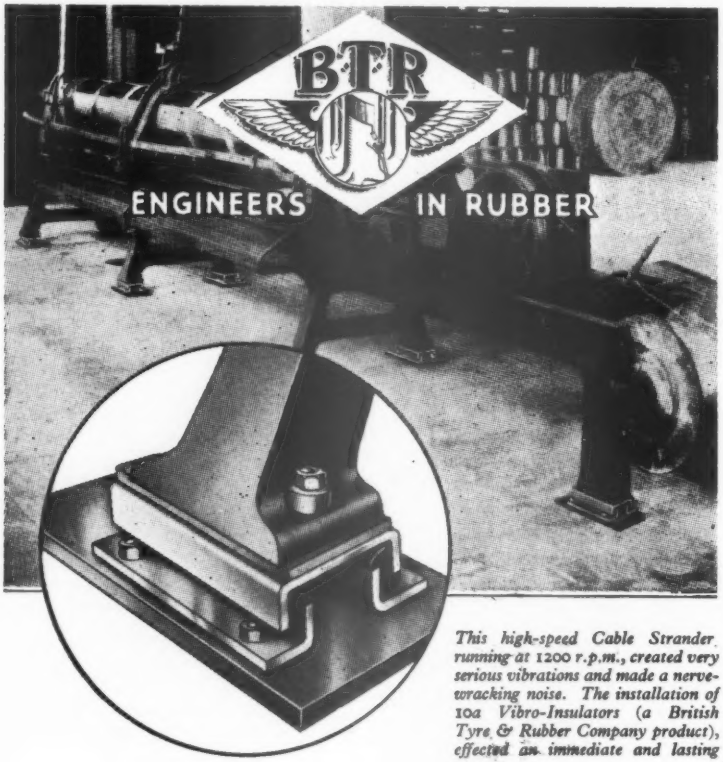


FIVE SIZES, with bar capacities (collets) ⅜" to 2" dia. Air and/or hand locking for collets and or chucks; various speed ranges—12 or 6 speeds (geared and non-geared) per range. Foot control of start, stop and reverse provides "third hand." 100% reliable automatic bar feed. Many optional attachments. **Please send for publications to Timbrell & Wright Ltd., Slaney Street, Birmingham, 4.**

Movable "joystick" fashion, the single speed-change lever both shifts gear in the two-speed gearbox and changes the speed of the two-speed motor. Thus, for each driving belt position and with the spindle running, any of four speeds is selected quicker than in a car and more easily. The time saved is important —particularly on the short-cycle repetition work usually done on capstans, where output is appreciably boosted.

TIMBRELL & WRIGHT

THE NAME TO WATCH IN CAPSTANS



This high-speed Cable Strander running at 1200 r.p.m., created very serious vibrations and made a nerve-wracking noise. The installation of 10a Vibro-Insulators (a British Tyre & Rubber Company product), effected an immediate and lasting cure.

RUBBER-TO-METAL components such as Vibro-Insulators for machinery, engine mountings, rubber-lined tanks and pipes, valves, bearings, etc., are outstanding products of the B.T.R /Silvertown Group but part only of its comprehensive service to industry.

Tyres, hose, belting, mouldings, linings and coverings are engineered to pay for themselves wherever rubber can lighten labour, prolong the life of manufactured goods or make their production and usage safer, cheaper, more efficient . . .

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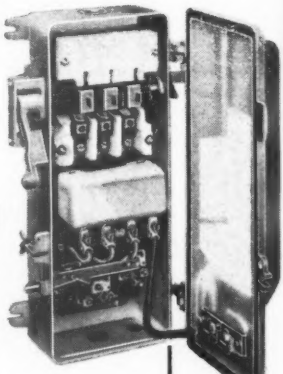
DIRECT-SWITCHING

CONTACTOR
STARTER
TYPE A·32 SIZE 1

Comprising a Starter and Isolator in *ONE* case, it is eminently suitable for use on Machine Tools to control the motor and provide for low voltage lighting. Triple pole interlocked isolating switch ensures safety, and no separate wiring saves wireman's time.



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THE DONOVAN ELECTRICAL Co LTD BIRMINGHAM, 9
ELECTRICAL ENGINEERS AND STOCKHOLDERS.
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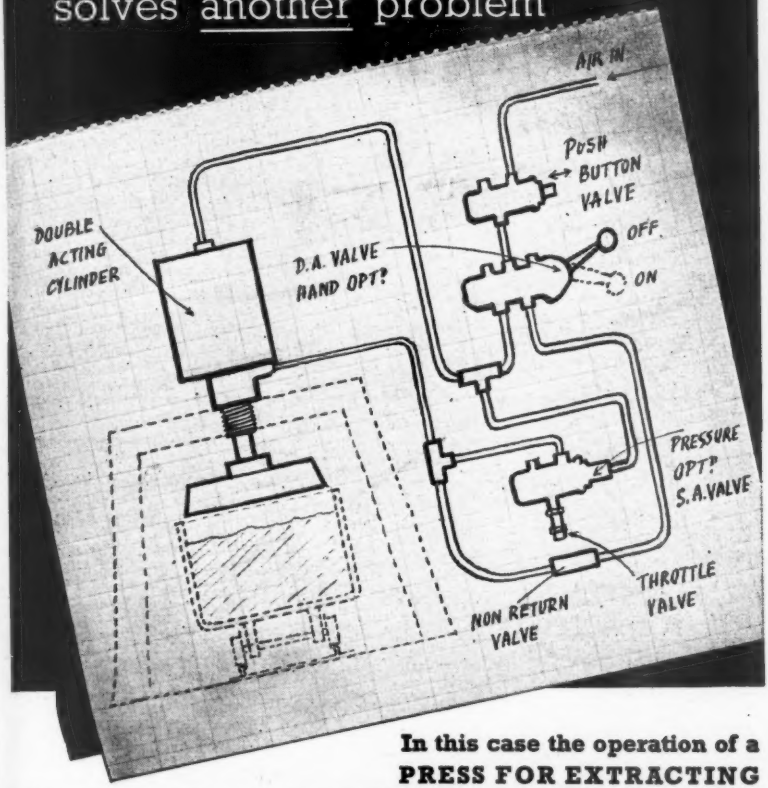

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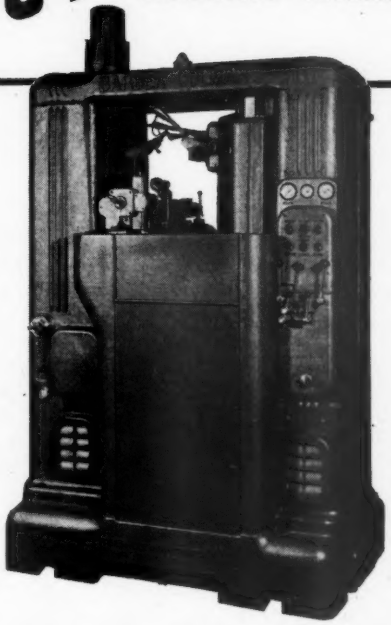

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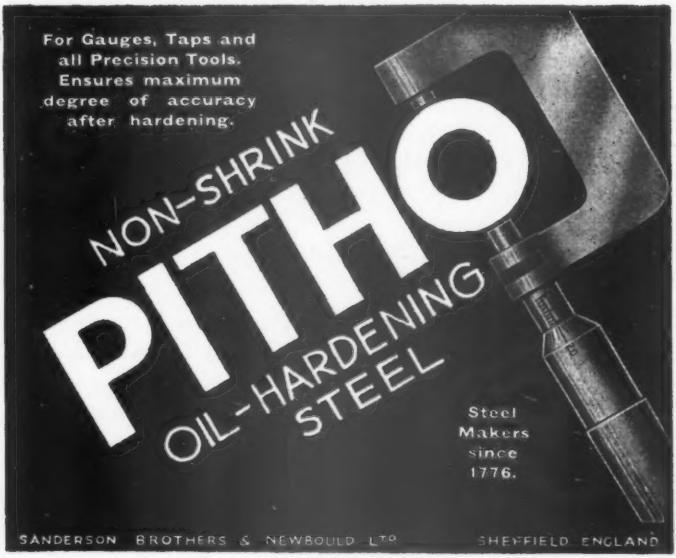
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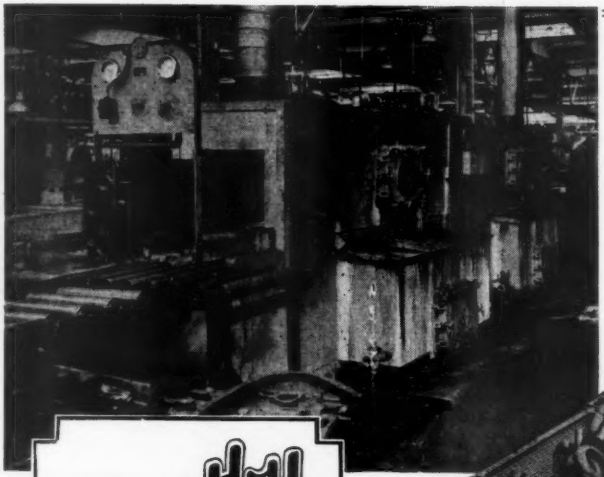

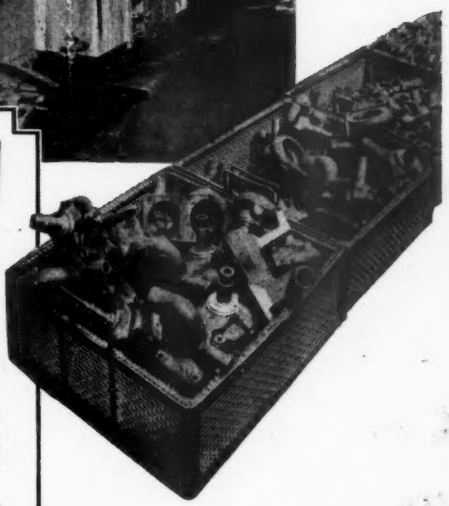

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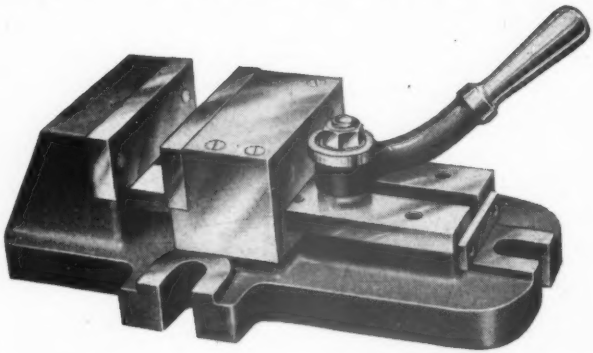

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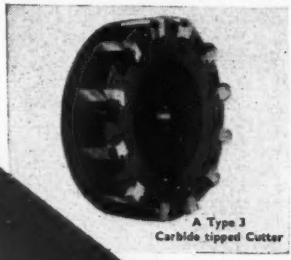
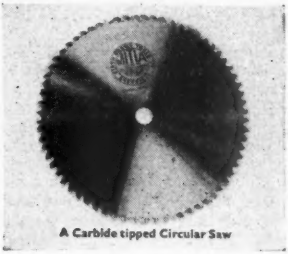


A Type 3
Carbide tipped Cutter



A Carbide tipped Circular Saw

A Carbide
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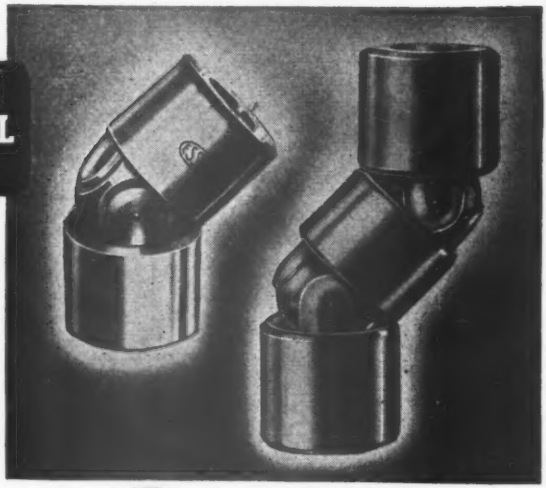

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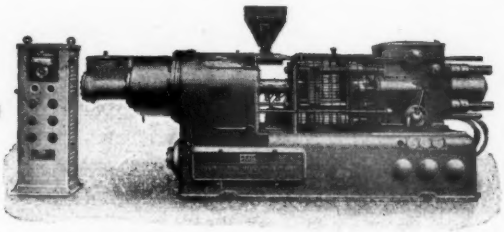

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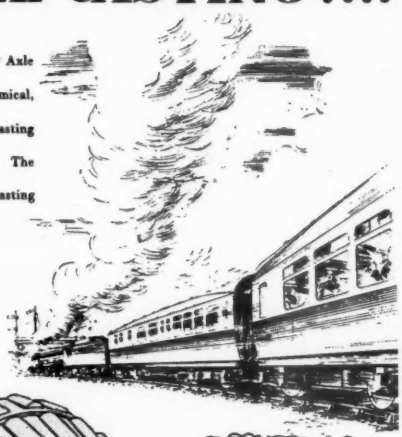

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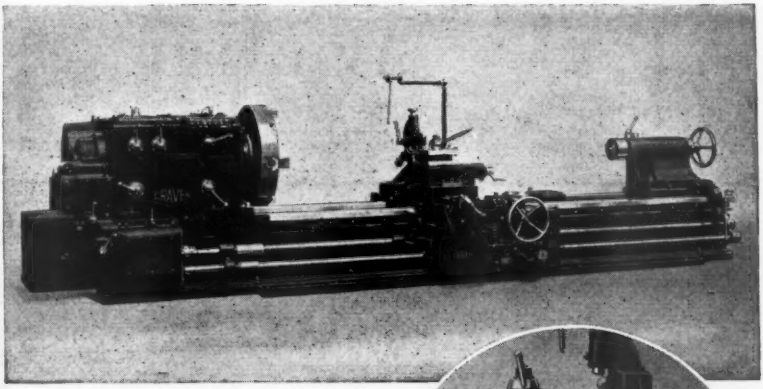

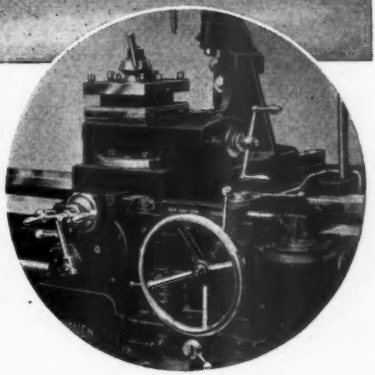

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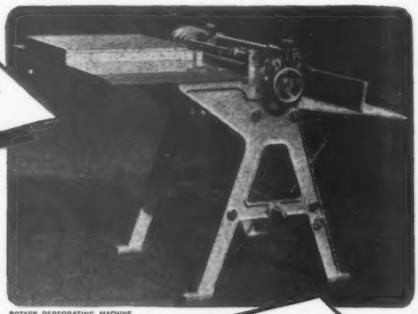

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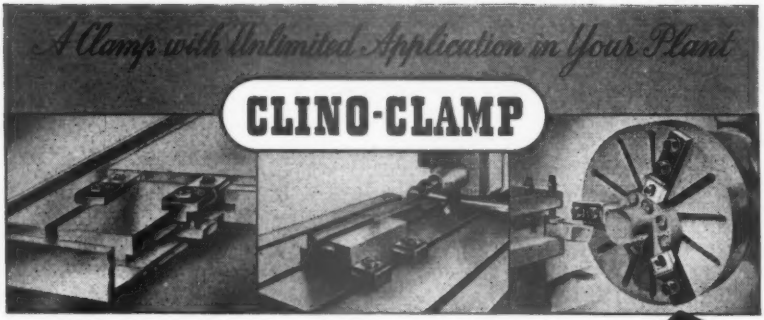

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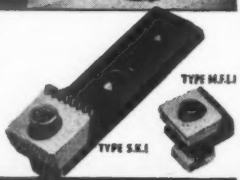

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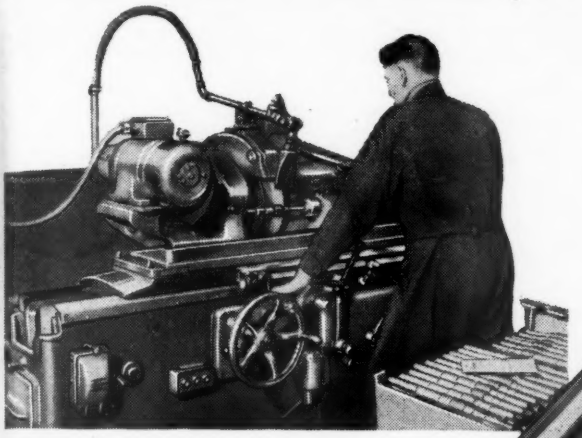

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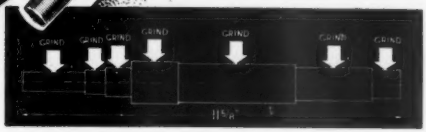

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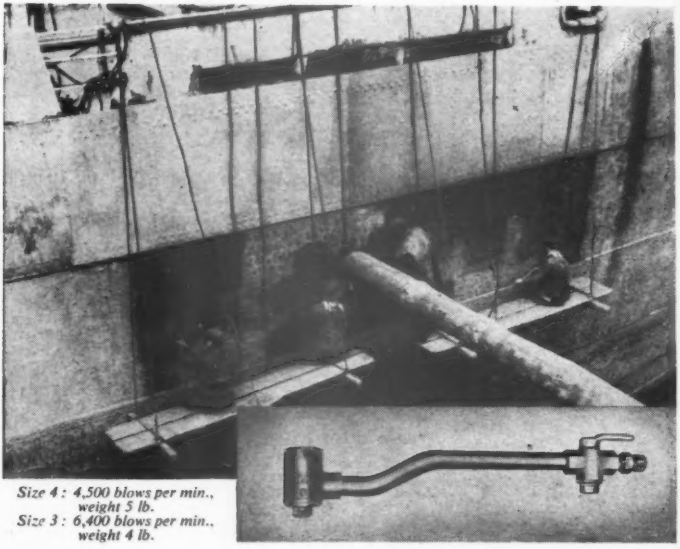
Holman Pneumatic Hammers designed for hard work on any scale



Size 4 : 4,500 blows per min., weight 5 lb.
Size 3 : 6,400 blows per min., weight 4 lb.

The Tungsten Carbide Tipped Piston of every Holman Pneumatic Scaling Hammer enables it to tackle the toughest, longest jobs—and never need regrinding. The tip will last as long as the piston itself. These hard-hitting hammers are extremely fast tools whose effectiveness lies in the speed rather than the weight of their blows. The piston is the only moving part. Full particulars and recommendations freely available on request.

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BROS. LTD.
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TELEGRAMS : AIRDRILL, CAMBORNE
SUBSIDIARY COMPANIES, BRANCHES AND AGENCIES THROUGHOUT THE WORLD

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All communications regarding advertisements should be addressed to the Advertising Managers, T. G. Scott & Son, Ltd., Talbot House, 9, Arundel Street, London, W.C.2. Phone : Temple Bar 1942.
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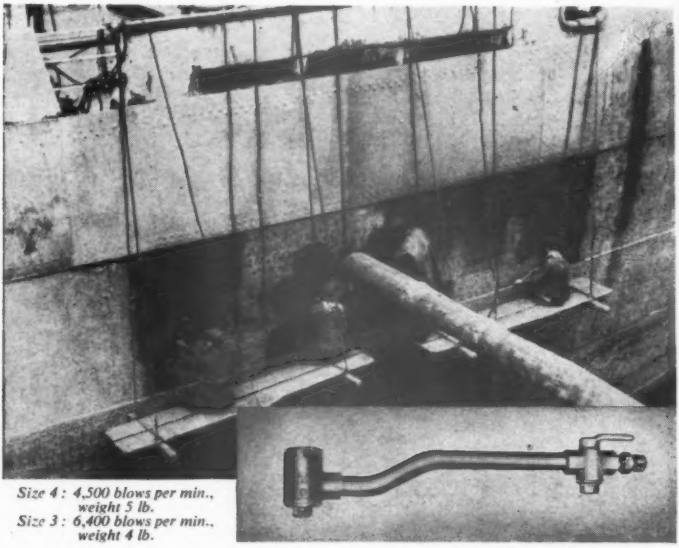

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